Agriculture Technical Work Group
Summary List of High Priority Mitigation Options

DRAFT

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Status of Option
		2012	2020	Total 2008 2020			
AW-1	Manure Digesters/Other Waste Energy Utilization	0.18	0.94	5.08	-20	-3.93	Ready for CAT review
AW-2	In-State Production of Biofuels and Biofuels feedstocks	0	1.45	4.59	264	57.53	Ready for CAT review
AW-3	Significantly Expand Source Reduction, Reuse, Recycling and Composting	1.30	4.76	29.21	-353	-12.10	Affirmed
AW-4	Agricultural Carbon Management	0.21	1.12	6.04	-110	-12.46	Ready for CAT review
	– No-till/Direct Seed; Dryland	0.14	0.69	3.82	1	0.24	
	– Hi-Res Farming; Irrigated	0.07	0.35	1.91	-68	-25.35	
	– Perennial Crop Soil C Storage	0.00	0.08	0.31	-28	-88.56	
AW-5	Agricultural Nutrient Management	0.03	0.16	0.86	-2	-2.48	Ready for CAT review
AW-6	Reductions In On-Farm Energy Use and Improvements in Energy Efficiency	0.01	0.06	0.31	-23	-76.28	Ready for CAT review
AW-7	Preserve Open Space/Agricultural Land	0.75	1.11	10.42	167	16.05	Ready for CAT review
AW-8	Support for an Integrated Regional Food System	*Not quantified*					Ready for CAT review
	Sector Total After Adjusting for Overlaps						
	Reductions From Recent Actions (table to be added below)						
	Sector Total Plus Recent Actions						

Washington Biomass Resource Inventory

A study conducted by the Washington Sate University Center for Bioproducts and Bioenergy provides a detailed inventory of the available biomass resources in Washington.[1] The table includes the total tonnage available from each resource, the nutrient composition (C an N, where available), and the potential utilization. The two categories of utilization are "cellulosic" or "AD." The resources marked "cellulosic" are primarily potential feedstocks for cellulosic ethanol and those marked "AD" are best suited for anaerobic digestion. Biomass that is anaerobically digested also may be used for field nutrient application. Although some resources may be used for both cellulosic ethanol and AD, only the primary utilization is included in the table below.[2] The purpose of this table is to display the available resources in Washington that are expected to be utilized by many of the options suggested by the AW TWG.

Biomass Type	**Annual Dry Tons**	**(%, dry basis)**		**Conversion**
		Carbon	**Nitrogen**	Process
Wheat Straw	1,121,419	43.20	0.61	Cellulosic
Grass Seed Straw	134,640	46.80	1.00	Cellulosic
Barley Straw	318,522	45.60	0.50	Cellulosic
Corn Stover	73,502	43.65	0.61	Cellulosic
Other Field Residue	159,174	NA	1.70	Cellulosic
Mint Slug	96,878	45.20	2.50	Cellulosic
Hops Residue	5,400	NA	NA	Cellulosic
Dairy Manure	457,032	44.70	2.24	AD
Cattle Manure	242,404	45.40	2.56	AD
Horse Manure	407,160	46.90	1.20	AD
Swine Manure	13,632	NA	NA	AD
Poultry Manure	784,577	39.57	2.93	AD
Logging Residue	1,901,072	50.30	1.03	Cellulosic
Forest Thinning	505,666	48.20	0.70	Cellulosic
Mill Residue	5,278,353	51.00	0.08	Cellulosic
Land Clearing Debris	418,595	48.10	0.64	Cellulosic
Cull Onions	2,322	NA	NA	AD

[1] Liao, W., C. Frear, and S. Chen. (2007). "Biomass Inventory Technology and Economics Assessment: Report 1 Characteristics of Biomass." *Washington State University Center for Bioproducts and Bioenergy*. Provided via e-mail by C. Kruger.

[2] "Conversion" column added by C. Kruger. Information in this column is not found in the previously cited report.

Biomass Type	Annual Dry Tons	(%, dry basis)		Conversion
		Carbon	Nitrogen	Process
Cull Potatoes	91,412	NA	NA	AD
Cull Apples	41,039	NA	NA	AD
Other Cull Fruit	8,934	NA	NA	AD
Asparagus Butts	667	NA	NA	AD
Apple Pomace	27,794	NA	NA	AD
Grape Pomace	19,254	NA	NA	AD
Other Fruit Pomace	11,865	NA	NA	AD
Cheese Whey	44,255	NA	NA	AD
Potato Solids	19,177	NA	NA	AD
Asparagus Trimmings	120	NA	NA	AD
Mixed Vegetables	14,744	NA	NA	AD
Poultry Feathers	7,932	NA	NA	AD
Poultry Meat Processing	5,479	NA	NA	AD
Beef Meat Processing	35,842	NA	NA	AD
Swine Meat Processing	280	NA	NA	AD
All Animal Mortalities	5,857	NA	NA	AD
Fish Waste	7,995	NA	NA	AD
Shellfish Waste	3,674	NA	NA	AD
Food Waste	246,011	NA	NA	AD
Yard Non-wood	421,489	42.40	1.60	Cellulosic
Other Organics	42,152	42.10	1.78	AD
Paper	2,428,084	49.30	0.70	Cellulosic
Wood Residue-MSW	834,057	47.60	1.20	Cellulosic
Yellow Grease	18,486	NA	NA	AD
Brown Grease	20,528	NA	NA	AD
Biosolids	94,820	40.4	0.80	AD

AW-1. Manure Digesters/Other Waste Energy Utilization

Mitigation Option Description

Anaerobic digestion of manure from concentrated animal feeding operations (CAFOs) - specifically dairy feedlots - is a critical and commercially available technology for reduction of direct methane emissions and the indirect offset of fossil fuel related energy production. Co-digestion of manure with wet organic wastes, such as food processing and packing wastes generates technical and economic benefits for both waste-streams.

Capture and recovery of "biogas" from wet organic wastes directly reduces emissions of methane to the atmosphere. Biogas is a low-BTU form of biologically produced natural gas, and therefore can be used to produce thermal and electrical energy as well as liquid fuel and alternative products.

Mitigation Option Design

- **Goals:**
    - Reduce methane emissions by diversion of open stored animal waste to anaerobic digestion – using waste from the equivalent of 150,000 dairy cows. This option covers large dairies where economies of scale make anaerobic digestion more feasibility (i.e., all cows from dairy CAFOs >500 head).
    - Reduce methane emissions through co-digestion of food or other organic wastes with animal manures – using approximately 200,000 tons of non-manure wastes annually. Pilot studies suggest a potential capacity of 15% for co-digestion. This goal is based on a 7-10% capacity of digesters covered under above goal.
    - Substitute bio-gas for non-renewable sources for the production of electricity – from methane from 2/3 of the target of goal #2.
    - Substitute bio-methane for non-renewable petroleum based vehicle fuels – using methane from 1/3 of the target of goal #2.
    - Substitute carbon and nutrient based co-products from anaerobic digestion for materials and nutrients derived through fossil fuel combustion and/ or mining and various other products.
- **Timing:**
    - Construction of anaerobic digesters for an average of the equivalent of the manure from 15,000 cows / year between 2010 and 2020.
    - Production of electricity as primary energy utilization technology through ~2015, with production of compressed / liquefied biomethane taking over as primary energy utilization technology after 2015.
    - Rerouting of food waste to digesters at an increasing rate of 20,000 tons per year until a total of 200,000 tons per year in 2020.

- **Coverage of parties:** Washington State University, Western Washington University, Washington State Department of Agriculture, Washington State Department of Ecology, Washington State Department of Transportation, public and private utilities, Conservation Districts, Municipal Government / Transit Fleets, private sector
- **Other:** Additional co-products generated in the anaerobic digestion process also have the potential to replace other CO_2 emission intense products such as materials and nutrients derived through fossil fuel combustion and/ or mining and various other products. Many of these products remain in the research and development pipeline, but will be commercially viable well before 2020. The potential for crediting reductions in CO_2 intensity is anticipated as significant.

Implementation Mechanisms

Continuation of existing public financial incentive programs (USDA Rural Development Sec. 9006 grants, Energy Freedom Loans, Federal Tax Credits) can provide sufficient cost-share to capitalize many farm-based AD projects in the near term. Funding sources for non-farm AD projects may be required. The two most significant remaining obstacles to near-term deployment of farm-based anaerobic digesters in Washington state are (1) an uncertain regulatory climate for CAFOs and (2) impediments to electrical generation and interconnection.

Mechanisms related to (1). The uncertain regulatory environment has been cited by Washington dairy farmers as a clear obstacle to the adoption of AD. AD is a substantial investment for dairies and the lack of clarity for how digesters will be treated in future CAFO regulations represents a substantial source of risk for the dairies.

- Provide a clear regulatory climate for both atmospheric / air emissions and terrestrial / aquatic nutrient pollution from CAFOs – including clear policies on how AD will be treated. This requires cooperation between a variety of state and federal regulatory agencies that have authority for regulatory compliance.
- Provide clear regulatory processes for co-digestion of non-manure wastes in on-farm anaerobic digesters. This includes streamlined AD facility permitting and land-use regulations favorable to co-digestion and directives related to the impact of co-digestion on dairy nutrient management plans.
- Facilitate the commercialization of prototype nutrient recovery technology "add-ons" to existing commercial AD technologies through cost-share programs. Nutrient recovery technologies are essential to meeting likely future emission and nutrient loading regulations – especially for on-farm digesters that co-digest food waste.
- Relevant plans should address AD as they are created, revised or reviewed. This possibly includes local Solid Waste Plans, Land-use Plans, Comprehensive Nutrient Management Plans, the State Beyond Waste Plan, etc..

Mechanisms related to (2). Current electrical power production offer sheets are quite favorable for many potential AD projects. However, there are still substantial obstacles to interconnecting AD projects to the grid, including substantial interconnection costs, lengthy interconnection study periods and the lack of interest by utilities in wielding power from willing sellers to willing buyers. Electrical generation and interconnection remain as the largest barriers to feasibility of

AD projects on smaller-scale dairies (<500 cow equivalent). In the long-term, these impediments to electrical power production will be overcome as simpler, more profitable alternative options for uses of bio-methane become commercially available.

- Reduce the allowable length of interconnection study periods by utilities
- Require utilities to wield power between willing sellers and willing buyers.
- Provide directives on allowable interconnection charges by utilities to digester CHP projects.
- Develop pilot projects with public transportation fleets (ie. transit, school buses, etc.) capable of using compressed bio-methane as a fuel source.

Related Policies/Programs in Place

1. **Washington Department of Ecology Beyond Waste Plan**: Recommendation ORG 6, http://www.ecy.wa.gov/beyondwaste/p_org06.html.
2. **Energy Freedom Loan:**
   - **South Yakima Conservation District** – $2 million.
   - **Port of Sunnyside,** Dairy Anaerobic Digester -- $1,972,715
   - **Tulalip Tribes**, Qualco Dairy Digester -- $1,500,266
3. **Ecology / WSU partnership**: Supplemental funding continues research on high solids anaerobic digester, and biomass inventory.
   - **Producing Energy and Fertilizer** (high solids anaerobic digester). http://www.ecy.wa.gov/biblio/0707024.html
   - **Biomass Inventory Technology and Economics Assessment** http://www.ecy.wa.gov/biblio/0707025.html
4. WSU Climate Friendly Farming Project / related WSU activities
   - Monitoring of commercial anaerobic digestion facilities for GHG mitigation, technical, and economic performance
   - Development and evaluation of AD co-products for improved economic performance: horticultural planting media; ammonia recovery, phosphorous recover
   - Development of novel anaerobic digestion technology
   - Evaluation of pathogen control by anaerobic digesters
   - Evaluation of co-digestion of municipal solid waste with animal manures
   - Evaluation of land application of digested substrates for efficacy as commercial fertilizers
   - Incubation of residual dairy solids after AD for stable carbon
   - Research and development of biogas scrubbing and compression technology for use as a liquid fuel – in partnership with Western Washington University's Vehicle Research Institute
   - Industry-oriented educational program, including workshops, field days, extension bulletins / publications, website.

Types(s) of GHG Reductions

- **Methane (CH_4):** methane is captured and typically combusted in an energy recovery system or flare. Small amounts of N_2O and CH_4 are emitted from the combustion process.

- **CO_2:** carbon dioxide is reduced when the methane is converted to energy and that energy is used to offset fossil-based energy (e.g., electricity, natural gas, etc.). Small amounts of N_2O and CH_4 are also reduced from the fossil-based energy that is offset.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2020 ($MMtCO_2e$):** 0.18, 0.94
- **Net Cost per $MtCO_2e$:** $0.18
- **Data Sources:**

  The study by Turnbull *et al*. provided average emissions per dairy, both with and without anaerobic digestion.[3] Sources that were consulted in the development of GHG reduction estimates resulting from the anaerobic digestion (and corresponding energy utilization) of organic solid waste (food waste) included Mohareb *et al.*[4] and Frear *et al.*[5] TWG input provided the parameters needed to calculate the GHG emissions reduced through offset electricity and transportation fuel.

  The capital cost of an AD system for a dairy operation is taken from an EPA study.[6] Other data sources for estimating the cost of meeting the portion of the option design targets relevant to dairies are the Gallo Farms study (Williams),[7] a California Institute for Energy and Environment study (Krich),[8] and a data table from the US Office of Energy Efficiency and Renewable Energy.[9] Key data sources for the organic waste portion of this

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[3] Turnbull, J.H., et.al. 2005. Greenhouse Gas Benefits of an Anaerobic Digester in the USA IEA Bioenergy: T38: 2005: 03. www.joanneum.at/iea-bioenergy-task38

[4] Mohareb, A.K., M. Warith, and R.M. Narbaitz. 2004. Strategies for the municipal solid waste sector to assist Canada in meeting its Kyoto Protocol commitments. Environ. Rev. 12: 71–95

[5] Frear C., M. Fuchs, B. Zhao, G. Fu, M. Richardson and S. Chen. 2005.Biomass Inventory and Bioenergy Assessment: An Evaluation of Organic Material Resources for Bioenergy Production in Washington State. A Collaborative Project between the Washington Department of Ecology and Washington State University's Department of Biological Systems Engineering.

[6] US EPA. (Year unknown, but no earlier than 2002). “United States of America Profile for Animal Waste Management.” Accessed on October 22, 2007 from: http://www.methanetomarkets.org/resources/ag/docs/animalwaste_prof_final.pdf

[7] Williams, D.W. (2006) . “Clean Fuels for California and the West. CHP for Hospitals, Universities, Landfills, Wastewater Treatment, Dairy and Food Processing Sites.” Presented on January 18, 2006 in Napa Valley; Napa, CA. Based on the Joseph Gallo Farms Dairy Manure Digester Case Study. Accessed on October 22, 2007 from; http://www.energetics.com/napavalleyCHPworkshop/pdfs/williams.pdf.

[8] Kirch, K. “Biomethane from Dairy Waste.” *California Institute for Energy and Environment*. Presentation created in 2006. Accessed on October 22, 2007 from: http://www.lgc.org/events1/docs/sjv_dairy_forum06/krich_biomethane_2006.pdf

[9] US Office of Energy Efficiency and Renewable Energy. “Properties of Fuels.” Data Table. Accessed on October 19, 2007 from: http://www.eere.energy.gov/afdc/pdfs/fueltable.pdf

option design are a BioCycle article (Kelleher)[10] and a graduate thesis completed at Columbia University (Ostrem).[11]

- **Quantification Methods:**

Biogas emissions reductions methodology (dairy)

The previously cited study by Turnbull *et al.* is a case study that provides life-cycle emissions of two 400-head dairy operations: one with anaerobic digestion (AD) and one without. The AD scenario is found to produce 13,892,103 kg CO_2e over its 50 year life, while the reference dairy produced 67,672,196 kg CO_2e over the same 50 years. Converting these numbers to metric tons and dividing by the lifecycle of the farms and the number of cows on each farm, the emissions per head were derived. The reference scenario produced 3.38 $MtCO_2$e per head per year, while the AD scenario produced 0.69 $MtCO_2$e per head per year. The incremental GHG reduction that is achieved through utilization of AD technology and energy capture on dairy operations is 2.69 $MtCO_2$e per head per year. This value is used as the per-head emission reduction factor for each head where the end product is biogas used for electricity consumption. The cumulative net emissions of this program through 2020 are estimated to be 2.22 $MMtCO_2$e. This result represents only the change in methane emissions from the BAU management scenario to the AD projects targeted in the option design.

Biogas emissions reduction methodology (MSW)

The study by Mohareb *et al* (2004) entitled, "Strategies for the MSW sector to assist Canada in meeting its Kyoto Protocol commitment", summarizes important data from other refereed articles regarding GHG emissions from MSW disposal.[12] Table X-1 gives net emissions for several processes for food waste components:

Table X-1: Emission Factors by Management Process

Process	Food ($MtCO_2$e/ton waste)
Net AD emissions	-0.25
Net Landfill emissions	1.03
Net Compost	-0.10

The policy option design calls for 200,000 tons of organic waste to be diverted to AD facilities, as opposed to the BAU management strategy. For the purposes of this analysis, the representative organic waste stream is food-processing waste. The available food packaging and processing waste in Washington State was 283,872 tons in 2005[13] The

[10] Kelleher, M. (2007) "Anaerobic Digestion Outlook for MSW Streams." *Biocycle*. Vol. 48, No. 8, p. 51. Accessed on November 6, 2007 from: http://www.jgpress.com/archives/_free/001406.html.

[11] Ostrem, K. (2004). "Greening Waste: Anaerobic Digestion for Treating the Organic Fraction of Municipal Solid Wastes." *Department of Earth and Environmental Engineering, Columbia University*. Accessed on October 22, 2007 from: http://www.seas.columbia.edu/earth/wtert/sofos/Ostrem_Thesis_final.pdf.

[12] Mohareb, A.K., M. Warith, and R.M. Narbaitz. 2004. Strategies for the municipal solid waste sector to assist Canada in meeting its Kyoto Protocol commitments. Environ. Rev. 12: 71–95. [NOTE]: Values in Table converted from $MtCO_2$e/MtWaste to $MtCO_2$e/ton Waste.

[13] Frear C., M. Fuchs, B. Zhao, G. Fu, M. Richardson and S. Chen. 2005.Biomass Inventory and Bioenergy Assessment: An Evaluation of Organic Material Resources for Bioenergy Production in Washington State. A

BAU diversion to compost was 5.8% for food waste. The remainder of waste is assumed to go to the landfill in the BAU scenario. Table X-2 below lays out the final diversion of the waste in 2020.

Table X-2: Food and Yard Waste Diversion

Process	Diversion
BAU Scenario	
AD Diversion	0%
Landfill Diversion	94.2%
Compost Diversion	5.8%
Policy Scenario	
AD Diversion	50%
Landfill Diversion	44.2%
Compost Diversion	5.8%

The policy scenario depicted in Table 2 assumes that all waste managed by AD will be diverted from landfills (GHG benefits of increased composting is addressed by AW-3). Therefore, the incremental GHG benefit for each ton of waste diverted from a landfill to an AD facility is the difference between the net landfill emissions and net AD emissions (from Table 1). The incremental reductions are estimated to be 1.28 $MtCO_2e$ per ton of dry food waste. Additionally, it is assumed that the emissions resulting from transportation of the waste are cut in half for waste diverted to anaerobic digestion facilities, resulting in a net reduction of 0.01 $MMtCO_2e$. The cumulative net emissions reduction for the increased anaerobic digestion of organic waste is 1.42 $MMtCO_2e$ through 2020.

Biogas electricity emissions reduction methodology (dairy & MSW)

The displacement of electricity currently generated in Washington by biogas derived from anaerobic digestion of manure and waste leads to an annual emission reduction of 0.16 $MMtCO_2e$ in 2020, according to analysis performed by AW TWG members.[14] This figure is based on a CO_2e reduction per cow for electricity estimated at 1.33 tons CO_2e/year/cow. CCS converted this number to metric tons CO_2e per cow by dividing by the conversion factor, 1.102. After the reduction factor was applied to the biogas from 100,000 cows – as set forth in the option design – CCS divided the difference between 0.16 $MMtCO_2e$ and the reductions solely from diaries by the number of waste tons earmarked for biogas-derived electricity generation. The resulting number is the emissions reduction factor for waste, 0.29 $MtCO_2e$ per ton of dry waste. The cumulative emission reduction derived from the displacement of current electricity production is 1.08 $MMtCO_2e$ through 2020.

Bio-methane vehicle fuel emissions reduction methodology (dairy & MSW)

[14] Personal communication; C. Kruger to B. Strode via e-mail on September 24, 2007.

One of the advanced technologies supported by the AW TWG is the purification of biogas into bio-methane. Compressed bio-methane can be used in the same manner as compressed natural gas (CNG), substituting for traditional liquid vehicle fuel. The bio-methane emission reductions derived from the displacement of liquid fossil vehicle fuel were calculated in the same manner as the displaced electricity reduction. The estimated reduction factor for dairies (conservative estimate) is 1.6 tons CO_2e /year/cow. This factor was converted into metric tons, and the remainder of the reductions estimated by the AW TWG (0.12 $MMtCO_2$e per year at 2020 target) was attributed to bio-methane derived from waste (0.72 $MtCO_2$e per ton of dry waste). The TWG states in the option design that bio-methane will begin to take over for biogas after 2015. Therefore, the cumulative emission reductions from this part of the goal are calculated from 2016 to 2020. These reductions are estimated to be 0.36 $MMtCO_2$e.

Target timing and total net emission reductions

The targets set forth in the "Timing" section above state that this policy is to achieve 10% of the goals in the first policy year, increasing linearly from that point, until the end of the policy period – 2020. The dairy portion of this option sets a target of 150,000 total cattle controlled, and the waste portion of this option sets a target of 200,000 tons per year diverted to AD facilities by 2020. Additionally, the option design calls for the conversion of a portion of the biogas generated each year after 2015 into bio-methane, which can be used as a substitute for compressed natural gas (CNG), a potential alternative transportation fuel. The target for 2020 is to convert one third of biogas from each source into bio-methane usable for vehicle fuel. Table X-3 below describes the annual schedule of policy application to dairy cows and food and yard waste:

Table X-3: Annual Policy Targets

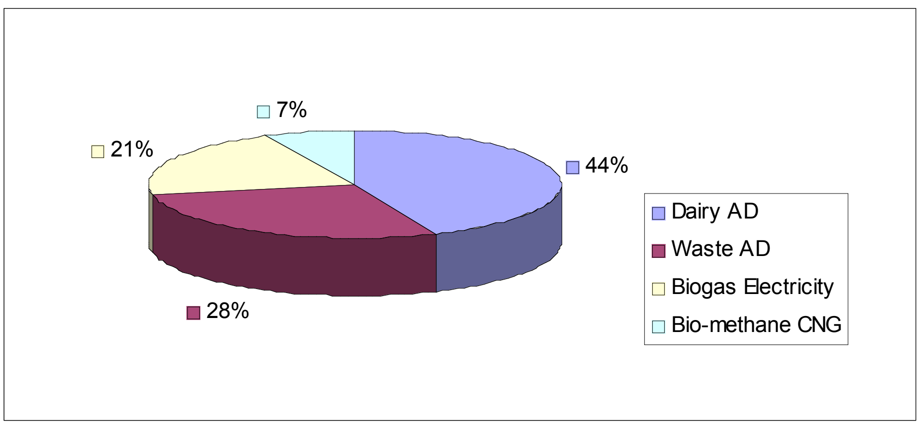
Year	Dairy Population Controlled (head)	Dry Food Waste Controlled (tons)	No. of Cows earmarked for biogas	No. of Cows earmarked for bio-methane	Tons of Waste earmarked for biogas	Tons of Waste earmarked for bio-methane
2010	-	-	-	-	-	-
2011	15,000	20,000	15,000	-	20,000	-
2012	30,000	40,000	30,000	-	40,000	-
2013	45,000	60,000	45,000	-	60,000	-
2014	60,000	80,000	60,000	-	80,000	-
2015	75,000	100,000	75,000	-	100,000	-
2016	90,000	120,000	80,000	10,000	106,667	13,333
2017	105,000	140,000	85,000	20,000	113,333	26,667
2018	120,000	160,000	90,000	30,000	120,000	40,000
2019	135,000	180,000	95,000	40,000	126,667	53,333
2020	150,000	200,000	100,000	50,000	133,333	66,667

For each year, the emission factors described above were applied to the dairy cows and tons of waste displayed in Table X-3. The result is a GHG reduction of 0.18 $MMtCO_2$e in 2012 and a reduction of 0.94 $MMtCO_2$e in 2020. The estimated cumulative GHG reduction throughout the policy period is 5.08 $MMtCO_2e$. These results are shown in Table X-4 and Figure X-1.

Table X-4: GHG Emission Reductions

Year	Net Emissions Reductions (Dairy, MMtCO2e)	Net Emissions Reductions (MSW, MMtCO2e)	Bio-gas Electricity Emission Reduction (MMtCO2e)	Bio-methane vehicle fuel reduction (MMtCO2e)	Avoided Emissions
2010	-	-	-	-	-
2011	0.04	0.03	0.02	-	0.09
2012	0.08	0.05	0.05	-	**0.18**
2013	0.12	0.08	0.07	-	0.27
2014	0.16	0.10	0.10	-	0.36
2015	0.20	0.13	0.12	-	0.45
2016	0.24	0.15	0.13	0.02	0.55
2017	0.28	0.18	0.14	0.05	0.65
2018	0.32	0.21	0.14	0.07	0.74
2019	0.36	0.23	0.15	0.10	0.84
2020	0.40	0.26	0.16	0.12	**0.94**
Totals:	2.22	1.42	1.08	0.36	**5.08**

Figure X-1: Share of Emission Reduction, by Reduction Type



Dairy Cost Effectiveness (biogas and bio-methane)

The cost effectiveness for the anaerobic digestion of manure from dairy farms includes the capital cost and O&M (operation and maintenance) cost of anaerobic digestion, as well as the revenue generated from offset electricity use. The value of offset electricity is \$0.064/kWh, a consistent figure used throughout the WA CAT process.[15] The capital cost is assumed to be \$1000 per head. The O&M cost is assumed to be \$38 per head. The total capital is multiplied by a capital recovery factor (CRF) of 0.096, which is based on a 5% discount rate and a payoff period of 15 years. The average electricity generated per cow

[15] Estimate derived from MWPCC data from RTF analysis, same source as marginal CO_2 emission rate for electricity reductions. This is the simple average (not levelized value) of the marginal dispatch costs for 2010, 2015, and 2020.

is based on 140 cubic meters of methane per head, a 75% collection rate, 35,310 Btu per cubic meter, and divided by 17,100 to calculate the per-head electricity generation factor of approximately 216.5 kWh/cow. The annualized costs are calculated by the following equation:

#Cows*Capital Cost*CRF + #Cows* O&M Cost – #Cows*kWh/Cow*$/kWh

The resulting annualized cost per cow is $120.11. This number is multiplied by the number of cows earmarked for additional biogas generation each year to achieve the cumulative net cost of $81.07 million.[16]

The cost of producing bio-methane for use in vehicles is assumed to be $11.80 per 1000 ft^3 of bio-methane, with a distribution cost of $3.00 per 1000 ft^3.[17] The number of cubic feet per cow is derived from the previously stated factor of 140 m^3 per head and the conversion factor of 0.028316 m^3/ft^3. The result is 4,929 ft^3/cow/year, with the cost per cow calculated to be $72.95. This option also creates a cost savings, due to displaced traditional vehicle fuel (gasoline). The bio-methane to gasoline energy equivalence is 127.77 ft^3 of uncompressed bio-methane per gallon of gas.[18] Dividing the annual ft^3 of bio-methane generated per cow by this equivalence, multiplied by a cost per avoided gallon factor of $2.50 (conservative), yields the gasoline savings per cow of $96.44. The result is a net cost savings of generating compressed bio-methane from dairy cows. The net cumulative cost savings is -$35.24 million.[19]

MSW Cost Effectiveness (biogas and bio-methane)

The cost of anaerobic digestion of high-solids MSW, such as food and yard waste, is estimated to be $75 per ton, including capital, O&M, and transportation costs.[20] This figure is based on the midpoint of expected costs (capital and O&M) for a 39,000 ton per year commercial food scrap anaerobic digestion facility in King County. One ton of waste can be used to generate an average of 170 kWh.[21] The difference between the per-ton cost and cost savings (the avoided cost of electricity, based on the same $0.064/kWh

[16] [NOTE]: This number is not levelized/discounted.

[17] Kirch, K. "Biomethane from Dairy Waste." *California Institute for Energy and Environment*. Presentation created in 2006. Accessed on October 22, 2007 from: http://www.lgc.org/events1/docs/sjv_dairy_forum06/krich_biomethane_2006.pdf

[18] US Office of Energy Efficiency and Renewable Energy. "Properties of Fuels." Data Table. Accessed on October 19, 2007 from: http://www.eere.energy.gov/afdc/pdfs/fueltable.pdf

[19] [NOTE]: This number is not levelized/discounted.

[20] Uhlar-Heffner, G. (2005). "Seattle Public Utilities Seek Anaerobic Solution." Book chapter in *Producing Power with Anaerobic Digestion*. Biocycle; JG Press.

[21] Ostrem, K. (2004). "Greening Waste: Anaerobic Digestion for Treating the Organic Fraction of Municipal Solid Wastes." *Department of Earth and Environmental Engineering, Columbia University*. Accessed on October 22, 2007 from: http://www.seas.columbia.edu/earth/wtert/sofos/Ostrem_Thesis_final.pdf.

used above), applied to the waste earmarked for electricity-generating biogas each year, yields a cumulative net cost savings of -$85.35 million.[22]

The cumulative net cost of producing bio-methane from the anaerobic digestion of food waste is $9.61 million.[23] This number is based on the above costs for anaerobic digestion and production of biogas. The Kirch presentation separates the cost of biogas generation from the cost of converting biogas to compressed bio-methane ($8.10 / 1000 ft^3). Therefore, since Kirch study applies specifically to dairies, the costs of converting and distributing ($3.00 / 1000 ft^3) the bio-methane are assumed to be the same for waste (although a different method of AD cost calculation is used). The cost of anaerobic digestion is the same as above ($75 per ton of waste). The anaerobic digestion of waste yields an average of approximately 100 m^3 per metric ton of waste, or 3,205 ft^3 per ton.[24] The gas-to-gasoline equivalence is the same as above (127.77 ft^3 = 1 gal). The resulting displaced gasoline savings per ton is $62.70, based on $2.50/gallon gasoline.

All costs associated with this option are displayed in Table X-5. The NPV of the net cost of this option is a savings of -$19.94 million and the levelized cost effectiveness is -$3.93 per $MtCO_2e$.

Table X-5: Net Policy Option Cost

Year	Dairy AD Biogas ($MM, midpoint)	DHSW AD Biogas ($MM)	Dairy AD bio-methane Liquid Fuel ($MM)	DHSW AD bio-methane Liquid Fuel ($MM)	Total Annual Cost ($MM)	GHG reductions (MMtCO2e)	Discounted Costs ($MM)	Discounted / Levelized Cost Effectiveness
2010	$0.00	$0.00	$0.00	$0.00	$0.00	-	$0.00	
2011	$1.80	-$1.90	$0.00	$0.00	-$0.10	0.09	-$0.09	
2012	$3.60	-$3.79	$0.00	$0.00	-$0.19	0.18	-$0.17	
2013	$5.40	-$5.69	$0.00	$0.00	-$0.29	0.27	-$0.25	
2014	$7.21	-$7.59	$0.00	$0.00	-$0.38	0.36	-$0.31	
2015	$9.01	-$9.48	$0.00	$0.00	-$0.48	0.45	-$0.37	
2016	$9.61	-$10.12	-$2.35	$0.64	-$2.22	0.55	-$1.65	
2017	$10.21	-$10.75	-$4.70	$1.28	-$3.96	0.65	-$2.81	
2018	$10.81	-$11.38	-$7.05	$1.92	-$5.70	0.74	-$3.86	
2019	$11.41	-$12.01	-$9.40	$2.56	-$7.44	0.84	-$4.79	
2020	$12.01	-$12.64	-$11.75	$3.20	-$9.18	0.94	-$5.63	
Totals	$81.07	-$85.35	-$35.24	$9.61	-$29.91	5.08	-$19.94	-$3.93

- **Key Assumptions:** In addition to the many assumptions stated above, some general assumptions were necessary to complete this analysis. It is assumed that all biogas is used to generate energy and that bio-methane is compressed for the use in transportation vehicles, offsetting gasoline. It is certainly possible to use biogas for thermal energy, as

22 [NOTE]: This number is not levelized/discounted.

23 *ditto*

24 Ostrem, K. (2004). "Greening Waste: Anaerobic Digestion for Treating the Organic Fraction of Municipal Solid Wastes." *Department of Earth and Environmental Engineering, Columbia University*. Accessed on October 22, 2007 from: http://www.seas.columbia.edu/earth/wtert/sofos/Ostrem_Thesis_final.pdf.

well as combined heat and power (CHP). Similarly, bio-methane has numerous other uses, other than vehicle fuel, especially on-farm use (fuel for farm equipment, furnaces, etc.). Another major assumption is that all other byproducts of anaerobic digestion are essentially value-less. This is generally not the case (revenue may be raised through the sale of digestate or application of digestate to fields as fertilizer). However, the value and quality of the byproducts of anaerobic digestion seem to be quite variable, making the analysis more manageable if the assumed net value of AD residues is zero.

Another assumption made regarding the analysis presented here is that the two key waste streams – dairy manure and organic waste – are treated as separate. In reality, it is seen that co-digestion can lead to a 10% improvement in energy recovery. However, this number is highly dependent on the composition of waste and the mix between manure and organic waste.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

- Enhancement and stabilization of dairy industry and the concomitant agricultural working land, with the addition of new revenue sources for energy production, organic waste tipping fees, and AD byproducts.
- More widespread access to AD facilities and other organic material processors will increase options for businesses and others with organic waste processing needs and in the long run will stabilize and possibly reduce their costs
- The shift from traditional manure storage and utilization to AD has the potential for a number of ancillary environmental benefits including improved water quality, air quality, and creation of byproducts, such as soil amendments, which also can have environmental benefits.
- Using bio-methane to substitute for petroleum vehicle fuels reduces air emissions of other air pollutants such as hydrocarbons, nitrogen oxides, and particulates
- Anaerobic digestion transforms feedstocks into digestate that can be used as a plant available fertilizer, displacing petroleum-sourced fertilizers.

Feasibility Issues

- Expansion of state support for alternative vehicle fuels research, development, production, distribution, and consumption beyond bio-diesel and ethanol to include bio-methane required

- State agency and local planning authority involvement necessary to ensure that rules allow food waste and other organic wastes to be processed through on-farm digesters or other facilities.
- Capital costs for AD technology
- Scale issues of the application of technology to smaller producers
- Farm nutrient plan issues with imported co-feedstocks digestion, exasperating on farm nutrient balance
- Bio-security issues for community digesters (used to reduce capital costs) serving multiple animal producers
- UTC and similar regulatory impediments limiting sale and export of energy to intermediary parties (electric, gas pipeline utilities

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

Appendix: References

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AW-2. In-State Production of Biofuels and Biofuels feedstocks

Mitigation Option Description

Washington state is distinctly different as an agricultural production region than the US Midwest – where corn and soybean-based biofuel production has dominated the landscape. Corn production in Washington is biophysically and economically limited to irrigated production as a rotational crop. Biophysical and economic limitations are even more constraining on current oilseed production in the state. Efforts are underway in both the public and private sector to increase the opportunity for Washington farmers to participate in the "traditional" biofuel markets of ethanol and biodiesel. Due to different potential feedstock crop choices and production practices for these fuels, it is likely that the GHG mitigation benefit of Washington ethanol, biodiesel, or other liquid biofuel feedstocks and production methods will be different than those based on Midwest production.

While Washington may not yet be competitive in traditional biofuel crops, we have a significant competitive advantage over other regions with non-traditional biofuel feedstocks and new crops – which ultimately will likely have more significant GHG mitigation benefit. Current research has identified the largest potential for current in-state biofuel feedstocks from: underutilized forest biomass; carbon-based municipal waste; and agricultural processing, field, and animal wastes. Furthermore, research has demonstrated that potential perennial biofuel crops, such as switchgrass, hybrid poplars, and other crops may be far more productive in our region than in other areas of the country.

Finally, any biofuels consideration should consider potential implementation trade-offs. For instance, removal of crop residues for biofuel generation will negatively affect soil carbon sequestration efforts. Biofuel promotion policies need to give consideration to environmental and economic trade-offs. Priority should be given to biofuels and feedstocks that maximize GHG mitigation benefits and minimize impacts on natural ecosystems. In particular, a Low Carbon Fuel Standard (LCFS) sets goals for reducing the carbon intensity of transportation fuels and creates a framework for promoting better performing liquid fuels. A Low Carbon Fuel Standard takes into account full lifecycle emissions and therefore provides new incentives and market value for feedstocks produced with lower emissions and better overall sustainability. We recognize that the CAT is considering a LCFS through Option T-11 in the Transportation TWG. The recommendations included in this Low-Carbon Biofuels option (AW-2) are integrally linked to implementation of the LCFS option (T–11). A LCFS would establish a demand for lower carbon fuels. This option addresses potential in-state feedstock supplies and research & development that are needed to meet the LCFS goal.

Mitigation Option Design

- **Goals:**

*The TWG decided to divide the goals for this proposal between quantifiable GHG reductions and other non-quantifiable goals for the development of a sustainable biofuel industry in the state. The intention of these goals is to push the state's biofuel industry beyond the existing biofuel / crop feedstock options and to give priority consideration to liquid fuels and feedstock crops that have greater relative GHG emission mitigation potential.

Quantifiable GHG mitigation goals:

- Increase utilization of waste biomass for biofuels by 3 million dry tons per year by 2020. A recent biomass inventory of Washington suggests a total of 17 million tons are available annually. This goal is set based on expert opinion of economic and technical feasibility to utilize the biomass.
    - Note: Policy options F-7 and AW-2 will be quantified together, incorporating waste biomass from agricultural and wood (forestry) biomass sources. The 3 million tons of waste biomass required by this goal will be split between F-7 and AW-2, with each sector utilizing 1.5 tons of waste biomass as cellulosic ethanol feedstock.
- Increase use of high biomass producing perennial bioenergy-feedstock crops to 80,000 acres by 2020. Acreage based on an assessment of the available crop land, taking into account economic feasibility (WA has roughly 300,000 acres of forage crops).
    - Note: The 80,000 acres of high biomass producing perennial bioenergy-feedstock crops required by this goal are the same acres required by the above-ground and soil carbon sequestration targets in AW-4. This option will measure the benefit of the conversion of the carbon captured by cellulosic biomass into ethanol.
- Promote *sustainable* production practices for the estimated 200,000 acres of likely feedstock production for ethanol and biodiesel feedstock crops. (Roughly 180,000 acres of corn and 20,000 acres of oilseed crops)

Other Biofuel feedstock crop development goals:

- Give priority consideration for "low-carbon" liquid fuel feedstocks adapted to Washington's unique biophysical and economic conditions.
- Evaluate the opportunity "next generation" biofuels such as compressed biomethane and biobutanol present for Washington-based feedstocks. Invest in research, development and commercialization of next generation biofuel conversion technologies suited to Washington's unique feedstocks.
- Using a lifecycle analysis, assess the energy balance and GHG mitigation benefits of Washington-based biofuels.

- **Timing**
    - Increase utilization of waste biomass for biofuels by 3 million dry tons (1.5 million for the agriculture and waste management sectors) per year by 2020. Initiation of this practice depends on further development of technologically viable biomass energy

conversion technologies (anaerobic digestion of "wet" biomass is ready and improving, thermochemical cellulosic technologies are ready, "biological" cellulosic technologies are estimated to be ready by 2015).

- Increase use of high-biomass perennial crops (hybrid poplar, switchgrass, etc.) to a total of 80,000 acres by 2020. Initiation of this practice depends on further development of technologically viable biomass energy conversion technologies (thermochemical cellulosic technologies are ready but economically marginal, "biological" cellulosic technologies are estimated to be ready by 2015).
- Promote *sustainable* production practices on the approximately 200,000 acres in the state now in annual rotation, which are likely to produce corn or oilseeds for the existing commercial biofuels: starch-based ethanol and biodiesel.

- **Coverage of parties:** WSDA, WSU, UW, CTED, Ecology, Conservation Districts, Private Sector
- **Other:** Washington State realizes that we cannot displace all petroleum based fuels with biofuels. We also realize that we have a solid opportunity to reduce a percentage of fuel imports with a regional biofuels production strategy by working with the Western States Climate Action Initiative states/provinces to develop integrated solutions.

Implementation Mechanisms

- Invest in Research, Development and Commercialization of next generation biofuel conversion technologies suited to Washington's unique feedstock. Mechanisms for investment include convening state-wide interests to determine development priorities, funding a competitive grant programs for research, development of pilot projects, and enhancement of the intellectual property offices at state research institutions.

- Develop the tools (baseline data sets, evaluation criteria and research capacity) to conduct Life-Cycle Assessments for in-state biofuels from seed to pump. These tools will enable the comparison of the trade-offs between GHG mitigation benefits, economic performance, and other environmental benefits of in-state produced biofuels.

- Determine the realistic potential for in-state biofuel production from in-state feedstocks by estimating the production of existing crops and biomass as well as new crops that have positive lifecycles assessments and that contribute to improving the sustainability of agricultural production systems.

- Fund educational programs (see implementation mechanisms in AW-4, 5, 6) that encourage the production of crops that can be used as biofuel feedstocks using sustainable production practices, such as direct-seed, high-residue, and / or organic systems.

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

CO_2: Lifecycle emissions are reduced to the extent that ethanol is produced with lower embedded fossil-based carbon than conventional (fossil) gasoline. Feedstocks used for producing ethanol can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (i.e., biogenic or short-term carbon). There are two different methods for producing ethanol based on two different feedstocks. Starch-based ethanol is derived from corn or other starch/sugar crops. Cellulosic ethanol is made from the cellulose contained in a wide variety of biomass feedstocks, including agricultural residue (e.g., corn stover), forestry waste, purpose-grown crops (e.g., switchgrass), and municipal solid waste. Local production of ethanol also decreases the embedded CO_2e of ethanol compared to importation from the current U.S. primary ethanol producing regions.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2020 ($MMtCO_2e$):** 0.00, 1.45
- **Net Cost per $MtCO_2e$:** $57.53
- **Data Sources:**

Lifecycle emission factors for gasoline and GHG reduction benefits of starch and cellulosic ethanol by fuel blend (E10 and E85) as compared to gasoline were obtained from Argonne National Laboratory's GREET model (v1.7). Conversion rate factors for generating cellulosic ethanol are based on personal communication with John Ashworth (NREL) to Steve Roe (CCS) (April 2007). Production cost differential estimates for cellulosic ethanol as compared to startch ethanol are based on DOE EIA analysis[25]. The organic waste cost premium estimate for use of waste biomass feedstocks as compared to bioenergy crops is based on a report from the California Energy Commission (2001)[26].

Table X-6. Lifecycle Emission Factors[27]

Fuel	**Emission Factor** (MtCO2e/MMgal)
Reformulated gasoline	8,814

Table X-7. GHG Reduction Benefit of Ethanol by Feedstock and Fuel Blend[28]

Technology	**Blend**	**Normalized Reduction (100% blend)**
Starch Based Corn Ethanol	E10	15.0%
	E85	20.7%
Cellulosic Ethanol	E10	72.0%

[25] DOE EIA analysis can be found at www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 2007.

[26] California Energy Commission (CEC). 2001. Costs and Benefits of a Biomass-to-Ethanol Production Industry in California. March 2001. Available at: http://www.energy.ca.gov/reports/2001-04-03_500-01-002+002A.PDF

[27] Argonne National Laboratory's GREET model (v1.7)

[28] Argonne National Laboratory's GREET model (v1.7)

	E85	97.9%

Table X-8. Incremental GHG Benefit of Cellulosic versus Corn Ethanol[29]

Fuel Blend	Incremental GHG Benefit
E10	57%
E85	77%

Table X-9. Cellulosic Ethanol Production Factors[30]

Time Period	Production Rate (gallons/dry ton)
2015 – 2019	90
2019 – 2020	100

- **Quantification Methods:**

Note: Policy options F-7 and AW-2 were quantified together using the same methodology. The GHG reductions and cost estimates provided below are attributable to cellulosic ethanol production from agricultural wastes and perennial bioenergy crops. GHG reductions and cost estimates for forestry-based residues are documented in F-7.

This quantification analysis does not include potential overlap with TLU-11. Preliminary analysis indicates that about 50% of the emissions reduced via AW-2 and F-7 are double-counted in TLU-11. Specific and detailed analysis of this and other overlaps will be presented at a later date.

– **GHG Reductions**

The benefits for this option are based on the incremental GHG benefit of production of cellulosic ethanol from agricultural biomass as compared to starch based corn ethanol. The benefits of using ethanol from starch-based production are accounted for as part of the analysis for TLU-11. Cellulosic ethanol production from agricultural biomass (Table X-10) was determined based on forest biomass utilization goals established by this policy option and reported conversion rates (Table X-9).

The GHG reductions are estimated based on the production of cellulosic ethanol targeted in this policy option (Table X-9), the lifecycle emission factor for gasoline (Table X-6) and the incremental GHG reduction benefit of cellulosic ethanol production over conventional starch-based ethanol. The incremental GHG reduction benefit of cellulosic ethanol production over conventional starch-based ethanol is based on reported values (Table X-8) and reflects projections for the E85 market share through 2020.

[29] Estimates are calculated based on GHG reduction benefits reported in Argonne National Laboratory's GREET model (v1.7).

[30] J. Ashworth. 2007. Personal Communication with Steve Roe (CCS).

Table X-10. Assumed Cellulosic Ethanol Production Schedule

Year	Agricultural Residue Biomass Utilization (dry tons)	Perennial Crop Feedstock (acres)	Perennial Crop Feedstock (tons)	Cellulosic Ethanol Production (MMgal)
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	250,000	13,333	149,733	35.98
2016	500,000	26,667	299,467	71.95
2017	750,000	40,000	449,200	107.93
2018	1,000,000	53,333	598,933	143.90
2019	1,250,000	66,667	748,667	179.88
2020	1,500,000	80,000	898,400	239.84

Estimates of agricultural biomass utilization are based on goals and timing outlined above for this policy option. By 2020, the target is the utilization of 1.5 million tons of waste biomass not from forestry feedstock (forestry feedstocks make up the other half of the 3 million-ton goal). The other target for the agriculture sector is to utilize high-biomass perennial feedstocks (switchgrass) from 80,000 acres per year by 2020. For the sake of this study, it is assumed that cellulosic ethanol production from the aforementioned feedstocks will not be feasible until 2015. Cellulosic ethanol production is assumed to increase linearly from 2015 to 2020 to meet the policy option goal.

Table X-11. GHG Reductions

Year	E85 Market Share	Cellulosic Ethanol Production for E85 (MMgal)	E85 Contribution to GHG Benefit (MMtCO2e)	Cellulosic Ethanol Production for E10 (MMgal)	E10 Contribution to GHG Benefit (MMtCO2e)	Total GHG Benefit (MMtCO2e)
2010	0%	-	-	-	-	-
2011	6%	-	-	-	-	-
2012	12%	-	-	-	-	-
2013	18%	-	-	-	-	-
2014	23%	-	-	-	-	-
2015	29%	10.50	0.07	25.47	0.13	0.20
2016	35%	25.21	0.17	46.74	0.23	0.41
2017	41%	44.12	0.30	63.81	0.32	0.62
2018	47%	67.23	0.46	76.67	0.39	0.84
2019	53%	94.54	0.64	85.34	0.43	1.07
2020	58%	140.07	0.95	99.77	0.50	1.45
Total						**4.59**

Cost Analysis

Costs for the incentives needed by this policy option are based on the difference in estimated production costs between conventional starch-based ethanol and cellulosic ethanol. The DOE EIA estimated that the cost to produce starch-based ethanol is $1.10/gal compared to $1.29/gal, or a difference of $0.19/gal (in $1998).[31] In 2006 dollars, the difference is $0.23/gal. An organic waste cost premium surcharge of $0.18/gal[32] is added to the production costs of cellulosic ethanol from forest residue as compared to starch-based ethanol production. The total costs for this option were estimated using the $0.23/gal incentive and the $0.18/gal organic waste cost premium multiplied by the annual cellulosic production by this policy option. Cost estimates are shown in Table X-12.

Table X-12. Cost Estimates of Cellulosic Ethanol Production from Forest Residue

Year	Production Cost Differential (MM$)	Waste Biomass Cost Premium (MM$)	Discounted Cost ($MM)
2010	$0.00	$0.00	$0.00
2011	$0.00	$0.00	$0.00
2012	$0.00	$0.00	$0.00
2013	$0.00	$0.00	$0.00
2014	$0.00	$0.00	$0.00
2015	$8.27	$4.05	$12.32
2016	$16.55	$8.10	$24.65
2017	$24.82	$12.15	$36.97
2018	$33.10	$16.20	$49.30
2019	$41.37	$20.25	$61.62
2020	$55.16	$24.30	$79.46
Total	$179.28	$85.05	$264.33

After discounting and leveling the costs from 2007–2020, the cost effectiveness is $57.53/MtCO2e.

- **Key Assumptions:** The key assumption (other than those stated in the text above) is that cellulosic ethanol can achieve the production levels in the near term (2015 production of 36 MMgal/yr) required by this policy option. This policy only represents the benefits of producing ethanol from ghg-superior – cellulosic – feedstocks. Incremental benefits above

[31] DOE EIA analysis can be found at www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 2007.

[32] California Energy Commission (CEC). 2001. Costs and Benefits of a Biomass-to-Ethanol Production Industry in California. March 2001. Available at: http://www.energy.ca.gov/reports/2001-04-03_500-01-002+002A.PDF

and beyond current ethanol benefits (starch-based) may be achieved through sustainable farming practices and the use of renewable energy to produce ethanol. However, these potential benefits are not considered in the quantified portion of this option.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

- WA State welcomes any and all out-of-state interests that are considering locating biofuel facilities here. WA State investments should be made with considerations of community impacts and economic development, and support projects of any scale that utilize low-carbon feedstocks optimized for our growing regions, and production methods measured by a state low-carbon fuel standard.

- One method to consider involves considering risk management of regional or community fuel potential over the creation of large scale facilities that require shipment of out of state feedstocks to in-state processing facilities. This decentralized approach would consider regional crop diversities in the right-sizing of processing facilities that support Washington-grown, Washington-owned biofuels.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AW-3. Significantly Expand Source Reduction, Reuse, Recycling and Composting

Mitigation Option Description

Expand source reduction, reuse, recycling and composting of household, business, industrial, agricultural, and construction-related waste streams to reduce greenhouse gas emissions. Based on data collected for calendar year 2005, existing recycling efforts reduced greenhouse gas emissions in Washington by almost 3.2 million metric ton CO_2 equivalents. This mitigation option, therefore, builds on existing programs and approaches and proposes to take advantage of newer market and business-based activities.

In addition to traditional recycling programs, a partial list of these approaches includes: source reduction (waste prevention) initiatives; expanding existing and encouraging more reuse, recycling, composting and processing businesses; establishing product stewardship programs; using environmentally preferable procurement practices; encouraging cradle-to-cradle design and manufacturing; facilitating safe byproduct "synergy" strategies; achieving a reduction of toxics in packaging and products to make them safer to manufacture, use and recycle while increasing their value and use in the market place; increasing closed-loop recycling and the percentage of recycled-content in products, and expansion of disposal bans.

Mitigation Option Design

- **Goals:**
  - Reduce the total amount of household and business waste by 15% and recycle at least 50% of the waste remaining (see Table X-13 for details);
  - Capture for composting[33] over 90 percent of compostable organics (see Table X-13 for details).

Table X-13. Goals by Household and Business Waste Sources

	Current Recycling Rate	Source Reduction Goal	Recycling Goal	Composting Goal
Aluminum Cans	33%	15%	60%	
Steel Cans	14%	15%	50%	
Glass	26%	15%	50%	
HDPE	20%	15%	50%	
LDPE	91%	15%	91%	
PET	32%	15%	50%	
Corrugated Cardboard	61%	15%	80%	

[33]Anaerobic digestion processes are an alternative to composting.

Newspaper	56%	15%	80%	
Office Paper	44%	15%	60%	
Food Scraps	17%	15%		80%
Yard Trimmings	56%	15%		100%
Mixed Waste Paper (general)	28%	15%	60%	
Mixed Metals	83%	15%	90%	
Mixed Plastics	2%	15%	25%	
Mixed Organics	50%	15%		90%

- **Timing:** Achieve 30% of the incremental increase in diversion by 2012. Achieve full goal implementation by 2020.
- **Coverage of parties:** All sectors of society in Washington State will be engaged in attaining this mitigation action, as will many levels of state and local government. The private sector will play a critical role by facilitating the transportation of recyclable materials to processors and composters, by providing processing and composting capacity, and through product stewardship actions. The private sector will likely be invited to take the lead in creating new markets for materials, through expanding existing businesses and services, and establishing new enterprises.
- **Other:** The most important of these goals is to significantly "source reduce" to reduce the generation of discarded material. Currently, while recycling rates are increasing, the overall generation of material discarded has increased dramatically as well. The average amount of garbage (including recyclables) produced by each person in the state increased by 5.3 percent from 2004 to 2005 (from an average of 7.5 pounds of waste per person each day in 2004, to an average of 7.9 pounds a day in 2005). In 2005, residents and businesses in Washington generated almost 18 million tons of solid waste.

  The overarching goal is to have continual improvement and progress toward an eventual "no waste" society, thereby dramatically reducing greenhouse gas emissions and attaining one of the cornerstone principles of sustainability. This can be enabled by taking steps toward product stewardship[34] and the design of products with greenhouse gas emissions, waste prevention, reuse and recycling in mind. This encourages manufacturers to design and manufacture, and for consumers to purchase, products geared towards end-of-life handling methods that conserve, capture, or "recirculate" resources in the most effective and efficient way possible.

  The current situation of increasing waste generation implies increasing consumption and production of goods. The greenhouse gas impacts of production are much larger than emissions from disposal facilities. Washington's greenhouse gas inventory does not fully assign to Washington State the greenhouse gas impacts associated with producing goods

[34] **Product stewardship** is a product-centered approach to environmental protection. It calls on those in the product lifecycle—manufacturers, retailers, users, and disposers—to share responsibility for reducing the environmental impacts of products. The greatest responsibility lies with whoever has the most ability to affect the lifecycle environmental impacts of the product. Please see the US EPA's Product Stewardship site at http://www.epa.gov/epr/ and the Northwest Product Stewardship Council site at http://www.productstewardship.net

that Washington residents and businesses consume. It is in changing the impacts associated with the manufacturing of these products that the greatest greenhouse gas reduction potentials are likely to be found.

A note on waste streams: The above-reported goal focuses on wastes generated by households and businesses ***outside*** the agricultural, construction, industrial, mining, and wood-products sectors. There are materials and waste streams ("other" wastes) from those sectors that have GHG emission implications – and are disposed as well as reduced, reused, recycled and composted – that were not considered at this time. Reasons for why this policy option focuses on the residential/business waste stream to the apparent exclusion of "other" wastes:

1) Current and historical data collection systems maintained by the Washington Department of Ecology are inconsistent in how these "other" wastes have been counted over time. For use in this policy, a particular waste stream had to be consistently defined and measured as both a disposed and recycled waste stream in three Washington Department of Ecology studies and reports: the 1992 Washington State Waste Characterization Study, the 2005 Disposal Data Report, and the 2005 Recycling and Diversion Report.

2) The publicly-accessible model which was used to calculate the GHG implications of source reduction, recycling, landfilling, and combustion programs (the EPA WARM model) includes input options for thirty-four material types commonly studied or managed by public sector solid waste program planners and managers. Excluded are wastes often found in the agricultural, construction and demolition, industrial, mining, and wood-products manufacturing sectors.

3) Some of the material type definitions used by the WARM model could not be correlated or reconciled with Washington state data. Only those waste types that matched were used in the calculations.

Some of the materials excluded from consideration because of data or modeling problems are: agricultural and silvicultural land clearing waste and agricultural manures; construction and demolition debris (including debris removal from old construction and scrap material from new construction); land clearing waste associated with construction projects; hazardous and non-hazardous industrial wastes which require specialized transport and disposal and which are generally not directly managed by local government; automotive wastes such as tires, used motor oil, and vehicle batteries; paint; wood waste (pre- and post-consumer); textiles and carpet; gypsum (pre- and post-consumer); photographic films; industrial film plastic; computers and computer parts; fluorescent light bulbs; consumer and industrial rubber materials; milk cartons, drink boxes and other similar containers; and asphalt and concrete [35]

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[35] The WA State list of materials tracked through the annual survey can be seen at http://www.ecy.wa.gov/programs/swfa/solidwastedata/recycle/CommoditySummary.xls.

The list of materials addressed in the WARM model can be seen at http://epa.gov/climatechange/wycd/waste/calculators/Warm_UsersGuide.html.

A note on collection systems for waste materials and recyclables: The WARM model, as used for the forecasts in this proposal, is "agnostic" concerning collection systems. Most recycling programs available to residents and small-to-medium sized business in Washington operate on the premise of source-separation. A resident or business separates materials destined for recycling from materials destined for disposal at the point of generation (e.g. kitchen, garage, loading dock, office desk). Some source-separation programs require a customer to further sort materials by type into multiple "streams" (e.g. paper in one bin, bottles in another). Others allow customers to place all recyclable materials in one container. When used at the residential and small business level, the latter are called "single-stream" or "co-mingled" recycling. Whether collected in multiple streams or a single stream, recyclables are often delivered to a processing location for a first or additional sort(s) before transport to a re-manufacturer or end-user.

An alternative to source-separated programs is the sorting of mixed wastes at a material recovery facility. The generator does not separate recyclables from non-recyclables but places everything into one can, cart, or container. Machines and laborers then sort the recyclable portion from the non-recyclable portion. This type of recycling system is not used frequently in Washington.

Local governments, through their comprehensive solid waste management plans, are empowered to establish recycling collection systems for residential waste streams. To date, local governments and their customers have made a two-decade and significant financial investment in source separation as the preferred strategy. While desiring to build on existing success, this policy option can be implemented through various collection means. Goals of advanced recovery may require examination of alternative collection systems.

Implementation Mechanisms

The effectiveness of a reduction/recycling/composting strategy is dependent on giving programs local flavor using local data. The first step in implementing this strategy should be a local waste disposal and recycling characterization audit in each of the state's 39 counties. The baseline data used to prepare this recommendation is nearly fifteen years old (1992 statewide waste audit). Local waste streams may differ significantly from the state average. Waste audits should be implemented using a common scenario with state funding in 2008 and 2009.

Additional crucial early steps:

- Full implementation of Washington's Beyond Waste Plan's current action items.
- Incorporate GHG reduction analysis and strategies in Beyond Waste Plan updates and next phase strategies.
- Fully implement and improve Washington State's Environmentally Preferable Procurement program and policies.

Legislative and budget proposals should be developed for the 2009 Legislature and a report and recommendations provided to the appropriate committees annually thereafter, until the goals are attained.

Specific details are provided below:

1. Local waste audits
    - development of statewide system model
    - development of statewide funding
    - implement audit
    - use results to influence local GHG reduction programs

2. Evaluate use of a model and index to measure and monitor GHG reductions
    - the EPA's WARM model was used for policy development
    - WARM model has some gaps, notably in failing to calculate source reduction potential for yard waste and food waste and it doesn't consider all the materials that are being recycled.
    - Investigate applicability or tweaks necessary to account for the actual types and location of disposal facilities in Washington State.[36]
    - Implement and evaluate use of the Washington State Consumer Environmental Index (CEI). CEI tracks changes over time in the ghg emissions and the impacts caused by the production, use and disposal of items purchased each year by Washington's consumers.

3. Build on existing source reduction and recycling programs, targeting commodities with the largest GHG reduction potential.

4. Fully implement and update Washington's Beyond Waste Plan. The current 5-year milestones and action items include key initiatives to increase recycling of industrial waste and organic materials, expand green building, reduce toxics and increase the ability to recycle products, and more. The next update and related funding priorities should further incorporate GHG emissions analysis and GHG reduction actions.

5. Fully implement and expand Environmentally Preferable Procurement policies and programs by state and local governments.

6. Encourage manufacturers to provide – and consumers to use – end of life management and upstream design solutions that reduce the GHG and other environmental impacts of product waste. Develop a framework policy for establishing product stewardship programs.

7. Encourage large retailers (e.g. Wal-Mart) to leverage buying power to encourage manufacturers to make the design solutions that reduce GHG and environmental impacts of product waste.

8. Establish a research and educational institute to address sustainable product design and manufacturing.

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[36] Given varying distances to transport waste and recyclables, using average distances and population "centroids" (as was used for the estimates in the current run of the WARM model) may not be the most accurate for program implementation

9. Ecology, CTED, Health and other appropriate agencies should coordinate reporting to the appropriate committees of the legislature, on an annual basis, progress made in reaching the goals and recommendations for legislation or other actions by the state.

10. Form an on-going technical work group of experts on reduction, reuse, recycling, composting, product stewardship and green business development to advise Ecology, CTED, Health and other appropriate agencies on actions needed to implement this action item and attain the policy goals. This could be accomplished by restructuring the Washington Solid Waste Advisory Committee (SWAC), creating a sub-committee of SWAC, or by creating an entirely new group. The technical work group's recommendations will be considered when reporting progress, next steps and recommendations to the legislature.

Related Policies/Programs in Place

This section identifies (and provides links to) some of the "foundational" policies and programs currently in place that are supportive of this proposal.

1. **Washington RCW 70.95** establishes a solid waste hierarchy of reduce/reuse/recycle and requires all local governments to have a solid waste management plan. http://apps.leg.wa.gov/RCW/default.aspx?cite=70.95

2. **Washington Department of Ecology Beyond Waste Plan**: http://www.ecy.wa.gov/beyondwaste/
   - Solid Waste Initiative, http://www.ecy.wa.gov/beyondwaste/SWIssues.html.
   - Hazardous Waste Initiative, http://www.ecy.wa.gov/beyondwaste/HazWasteIssues.html
   - Small Volume Toxics Initiative, http://www.ecy.wa.gov/beyondwaste/reduceToxics.html
   - Organics Initiative, http://www.ecy.wa.gov/beyondwaste/increaseOrganics.html.
   - Industrial Waste Initiative, http://www.ecy.wa.gov/beyondwaste/reduceWaste.html.
   - Green Building Initiative, http://www.ecy.wa.gov/beyondwaste/increaseGB.html.
   - Measure Progress, http://www.ecy.wa.gov/beyondwaste/measureProgress.html

3. **Electronic Product Recycling Program**: Manufacturers required to provide recycling for covered electronics. http://www.ecy.wa.gov/pubs/wac173900.pdf.

4. **Ecology Coordinated Prevention Grants:** Available to local governments to develop and implement their hazardous and solid waste management plans. http://www.ecy.wa.gov/programs/swfa/grants/cpg.html.

5. **Ecology Public Participation Grants:** Public Participation Grants provide funding to citizen groups and not-for-profit public interest organizations to provide public involvement in monitoring the cleanup of contaminated sites and prevent pollution by reducing or eliminating waste at the source. http://www.ecy.wa.gov/programs/swfa/grants/ppg.html.

6. **Washington State Environmentally Preferable Purchasing Policies:** The State of Washington has a broad legislative and policy mandate for environmentally preferable purchasing activities by state agencies. This mandate is articulated in state executive orders, laws and rules. Executive Orders (EOs) are issued by the Governor to direct state agencies and officials in their execution of established laws or policies. The Revised Code of Washington (RCW) is the compilation of all permanent laws now in force in the State of Washington. The Washington Administrative Code (WAC) is the compilation of all rules promulgated by state agencies.

   A brief summary of environmentally preferable purchasing executive orders, laws and rules for state agencies is listed below. For more information on specific activities or directives contained within each order, law or rule, follow the link provided.

   Executive Order 02-03 SUSTAINABLE PRACTICES BY STATE AGENCIES
   This Executive Order calls for each state agency to establish sustainability objectives and modify their purchasing practices in order to:

   - minimize energy and water use
   - shift to clean energy for both facilities and vehicles
   - shift to non-toxic, recycled and remanufactured materials in purchasing and construction
   - expand markets for environmentally preferable products and services
   - reduce and eliminate waste

   Each agency is required to prepare a biennial Sustainability Plan guided by the above objectives and an annual report on its progress in implementing its Sustainability Plan. The Office of Financial Management must designate a Sustainability Coordinator to help state agencies meet the goals of the Executive Order.

   Executive Order 05-01 ESTABLISHING SUSTAINABILITY AND EFFICIENCY GOALS FOR STATE OPERATIONS
   The Executive Order directs state agencies to achieve specific sustainability goals and required actions:

   - incorporate green building practices based on Leadership in Energy and Environmental Design (LEED) standards into new building construction and major remodeling projects
   - achieve a target of 20% reduction in petroleum use in the operation of state vehicles by 2009
   - employ professional vehicle fleet management practices to achieve more fuel efficient and low emission agency fleets
   - significantly reduce office paper purchases by 30%, increase the purchase of environmentally preferable paper to at least 50%, recycle all used office paper, and increase the purchase of post-consumer recycled janitorial products
   - reduce energy purchases by 10% from FY 2003 to 2009

Executive Order 04-01 PERSISTENT TOXIC CHEMICALS
The Executive Order directs state agencies to take steps to reduce persistent toxic chemicals in Washington State's environment. Specifically, it directs:

- General Administration (GA) to make available for purchase products that do not contain persistent toxic chemicals. If such products are not available, products with the least amount of persistent toxic chemicals shall be made available.
- Each state agency to adopt measures to reduce purchase of goods that contain persistent toxic chemicals. Agencies are directed to report annually on progress in meeting these measures.
- Department of Ecology to establish through rule specific criteria for use in identifying persistent toxic chemicals.

Executive Order 07-02 WASHINGTON CLIMATE CHANGE CHALLENGE:
the Executive Order establishes the goal of reducing greenhouse gas emission in the state of Washington to:

- 1990 levels by 2020 and to 25% below 1990 levels by 2035.

Chapter 43.19 RCW Department of General Administration
This statute, which is GA's enabling legislation, provides a broad legislative basis for state purchases of recycled content and energy saving products. It also provides the flexibility to allow GA to award state contracts based on environmental considerations. It establishes that factors beyond price, including past performance and life cycle costing, are to be used in determining the "lowest responsible bidder."

Chapter 43.19A RCW Recycled product procurement
This statute was established to substantially increase the purchase of recycled content products by local and state government agencies. This statute

- established numeric goals for statewide purchase of recycled content paper and compost
- directs GA to develop a strategy for state agencies and GA to increase purchases of plastic products, retread and remanufactured tires, motor vehicles, lubricants, latex paint and lead acid batteries having recycled content.

Chapter 43.19.539 RCW Purchase of Electronic Products Meeting Environmental Criteria
This statute requires the Department of General Administration to

- establish purchasing and procurement policies that establish a preference for electronic products that meet environmental performance standards relating to the reduction or elimination of hazardous materials.
- ensure that their surplus electronic products, other than those sold individually to private citizens, are managed only by registered transporters and by processors meeting the requirements of RCW 70.95N.250.

- ensure that their surplus electronic products are directed to legal secondary materials markets by requiring a chain of custody record that documents to whom the products were initially delivered through to the end use manufacturer.

Chapter 39.35D RCW High-performance public buildings
Green Buildings
State-owned buildings and schools shall adopt recognized standards for high-performance public buildings and allowing flexible methods and choices in how to achieve those standards. Public agencies and school districts shall document costs and savings to monitor this program and ensure that economic, community, and environmental goals are achieved each year.

Chapter 70.95M RCW Mercury Education Reduction Act
Mercury Education Reduction Act
The Mercury Education Reduction Act (MERA) mandates General Administration to give priority and preference to the purchase of equipment, supplies, and other products that contain no mercury-added compounds or components.

WAC 236-48-096 Bid Award Preference
Washington Administrative Code 236-48-096 establishes a bid award preference for recycled products. When determining the lowest responsive bid, bids for goods certified as recycled are to be given a preference of 10% of the amount of the bid.

7. **Local governments:** Local governments have instituted plans and a wide range of programs and policies to establish reduction, reuse, recycling, and composting activities, to increase procurement of environmentally preferable products, and to ban specific materials from disposal. Program information is shared through a variety of means including Recycling Coordinator meetings, Solid Waste Policy Forum, and the State Solid Waste Advisory Committee. Product stewardship efforts are coordinated through the Northwest Product Stewardship Council. http://www.productstewardship.net/

8. **Businesses:** Many businesses have instituted internal policies to address waste and recycling and some have begun to implement product stewardship programs. Washington has many businesses engaged in the business of reuse, recycling, composting, and processing, including reuse organizations such as Goodwill, and businesses that refurbish electronic equipment and resell building materials. Other businesses incorporate recycled content into their products. Green building activities are coordinated by a variety of business interests including the Built Green program of Master Builders and the Cascadia Green Building Coalition, and others.

9. **Non-Governmental Organizations**: A variety of NGOs have internal policies and work on implementation and coordination of policies and programs. These include Washington Citizens for Resource Conservation, Washington State Recycling Association, Washington Organic Recycling Council, Washington Toxics Coalition, Pollution Prevention Resource Center, and others.

Types(s) of GHG Reductions

CH_4: Methane reductions from avoided emissions from waste placed into landfills.

CO_2: CO_2 reductions from lower energy consumption associated with a reduction of wastes generated (e.g. energy used to create products or packaging). Also included are GHG reductions from lower energy consumption associated with utilizing recycled materials for production versus virgin materials.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **GHG Reductions ($MMtCO_2e$) in 2012, 2020:** 1.30. 4.76
- **Net Cost ($/$MtCO_2e$):** **-**$12.10
- **Data Sources:** The 2005 baseline waste generation and diversion rates were provided by the AW TWG.[37] These data are derived from the 1992 Washington State Waste Characterization Study,[38] 2005 disposal data,[39] and the 2005 Recycling and Diversion Report.[40] The GHG reductions are estimated using the US EPA Waste Reduction Model (WARM).[41] The data used to establish the cost effectiveness of the goals presented in this option are supported by the personal and professional project planning and program development experience of the AW TWG.
- **Quantification Methods:**

  GHG Reductions

  The 2005 baseline generation and diversion was derived through an extrapolation of diversion rates from the 1992 Waste Characterization Audit to the 2005 disposal data. Information from the 2005 Recycling and Diversion Data report was also incorporated into these data.[42] For the purposes of this analysis, the only waste that is considered to be "generated" is waste composed of materials that may be analyzed with the EPA WARM. Waste combustion is utilized for the management of approximately 6% of non-diverted waste in WA. The share of non-diverted waste that is combusted is assumed to remain constant throughout the policy period. These figures include waste exported to landfills in Eastern Oregon. Although these emissions are not considered in the WA I&F, the reductions from

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[37] S. Jackson and S. Wamback. Personal communication with K. Bickel and S. Roe. Forwarded to B. Strode via e-mail on September 11, 2007.

[38] 1992 Waste Characterization Study. Washington State Department of Ecology. Accessed on September 18, 2007 from http://www.ecy.wa.gov/programs/swfa/solidwastedata/waste.asp.

[39] 2005 Solid Waste Disposal Data, by Facility. Washington State Department of Ecology. http://www.ecy.wa.gov/programs/swfa/solidwastedata/disposal/05facilitytypes.xls.

[40] Solid Waste in Washington State: Fifteenth Annual Status Report. 2006. Washington Department of Ecology. http://www.ecy.wa.gov/pubs/0607024.pdf.

[41] Links to WARM documentation, a list of material types recognized by WARM, and User's Guides for WARM can be found on the EPA website at http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteWARMUsersGuide.html.

[42] The 2005 BAU diversion data was calculated by S. Jackson and S. Wamback; AW TWG members.

reduced export of waste are counted in the numbers presented in Table X-14. The 2005 baseline diversion data is displayed in Table X-14 below:

Table X-14: 2005 Baseline Waste Generation and Diversion (tons)

	Generated	Recycled	Landfilled	Combusted	Composted	Recycle and Compost %
Aluminum Cans	46,208	15,441	29,013	1,754	0	33.42%
Steel Cans	86,014	12,133	69,670	4,211	-	14.11%
Glass	315,310	82,773	219,282	13,255	-	26.25%
HDPE	45,870	9,319	34,468	2,083	-	20.32%
LDPE	17,830	16,209	1,529	92	-	90.91%
PET	26,435	8,534	16,881	1,020	-	32.28%
Corrugated Cardboard	933,811	565,698	347,131	20,982	-	60.58%
Newspaper	460,154	259,157	189,540	11,457	-	56.32%
Office Paper	132,976	58,661	70,079	4,236	-	44.11%
Food Scraps	720,615	-	561,297	33,928	125,390	17.40%
Yard Trimmings	886,928	-	367,255	22,199	497,474	56.09%
Mixed Paper (general)	1,177,563	327,261	801,835	48,467	-	27.79%
Mixed Metals	1,376,520	1,144,327	218,958	13,235	-	83.13%
Mixed Plastics	456,920	7,734	423,582	25,604	-	1.69%
Mixed Organics	486,746		230,638	13,941	242,167	49.75%
Total	**7,169,900**	**2,507,247**	**3,581,158**	**216,464**	**865,031**	

The volume of waste generated in each year is assumed to grow at the same rate as the population. The projected population growth in WA is consistent with the projections used in the WA Inventory and Forecast (I&F). Based on this projection, the population is expected to increase by 13.13% from 2005 to 2012, and 10.42% from 2012 to 2020. The 2005 baseline waste generation was multiplied by the population growth rate from 2005 to 2012 to yield the business as usual (BAU) waste generation and diversion projections. The 2020 BAU waste generation was determined by multiplying the 2012 forecast by the expected population growth from 2012 to 2020 (10.42%).

The 2012 policy scenario represents an increase in diversion (recycling, composting, and source reduction) equal to 30% of the difference between the 2020 diversion goals and the BAU scenario. The 2020 policy scenario represents the estimated waste diversion should all policy targets be met. The source reduction goal is applied in full (15% of waste generated), given that the source reduction goal does not exceed the difference between waste generated and the compost or recycle goal.

Each scenario (4 total) was entered into WARM. The difference between the policy scenario and BAU scenario GHG reduction is the incremental GHG emission reduction resulting from the targets set forth in this option. WARM does not allow input for source reduction for the following waste materials: food scraps, yard trimmings, mixed paper (general), mixed metals, mixed plastics, and mixed organics. This modeling barrier may be remedied by subtracting the source reduction from the "waste generated" and "tons landfilled" columns for the baseline worksheet in the policy scenario and entering the policy scenario, as calculated above, into the policy worksheet. The WARM results are displayed in Table X-15 below:

Table X-15: Incremental Waste Reduction (tons) and WARM Results

	Generated	Recycled	Composted	Source Reduced	Landfilled	Combusted	Diversion %	WARM GHG Benefit ($MtCO_2e$)
2012 BAU Scenario	8,111,308	2,836,449	978,610	-	4,051,364	244,886	47.03%	13,069,550
2012 Policy Scenario	8,111,308	3,185,379	1,330,374	365,009	3,035,274	195,272	60.17%	14,365,507
2012 Incremental Diversion	**-**	**348,931**	**351,764**	**365,009**	**(1,016,089)**	**(49,615)**	**13%**	**1,295,957**
2020 BAU Scenario	8,956,506	3,132,006	1,080,581	-	4,473,516	270,403	47.03%	14,431,409
2020 Policy Scenario	8,956,506	4,416,304	2,375,308	1,059,572	1,038,511	66,812	87.66%	19,193,663
2020 Incremental Reduction	**-**	**1,284,297**	**1,294,727**	**1,059,572**	**(3,435,004)**	**(203,592)**	**37.91%**	**4,762,254**

Net Policy Cost[43]

This mitigation option requires a significant investment in human, social, and physical capital to implement. However, the reduction of total waste generated, as well as diversion mechanisms such as recycling and composting, present a significant potential for cost savings. The costs associated with this option are broken down into three categories: planning costs, implementation costs, and facility development and operation costs. The cost savings are attributed to the costs averted through the diversion of waste from landfills, as well as revenue generated by the sale of compost.

The planning costs for this option include a $1 per capita expenditure for a State-wide waste audit[44] and a $1 million cost for the development of a Washington State-specific waste reduction model to track the GHG benefits of the proposed diversion programs. These planning costs are assumed to be one-time costs that take place prior to the end of 2008. Therefore, the total cost for the waste audit program is largely based upon the 2008

[43] S. Jackson and S. Wamback. Personal communication with K. Bickel and S. Roe. Forwarded to B. Strode via e-mail on September 11, 2007.

[44] Based on similar characterization project conducted in Pierce County in 1995 and another planned for 2008

population, as projected in the WA I&F. The total planning costs – annualized over the policy period at 5% interest – are approximately $860,000 per year through 2020.

The implementation costs include new education programs for waste reduction, as well as recycling and composting.[45] The implementation of this option is also expected to require the establishment of a research and educational institute at a cost of $1.5 million per year. The two education programs are expected to each cost $1 per capita annually. The total annual cost of these programs are based on the population projections used in the WA I&F. The implementation costs are displayed in Table X-16 below:

Table X-16 Implementation Costs for Waste Diversion Programs

Year	Population	Waste Reduction Education ($MM)	New Recycling and Composting Education ($MM)	Research and Educational Institute ($MM)	Total Implementation Costs ($MM)
2008	6,630,676	$6.63	$6.63	$1.50	$14.76
2009	6,751,441	$6.75	$6.75	$1.50	$15.00
2010	6,865,990	$6.87	$6.87	$1.50	$15.23
2011	6,975,055	$6.98	$6.98	$1.50	$15.45
2012	7,077,871	$7.08	$7.08	$1.50	$15.66
2013	7,175,504	$7.18	$7.18	$1.50	$15.85
2014	7,270,759	$7.27	$7.27	$1.50	$16.04
2015	7,364,079	$7.36	$7.36	$1.50	$16.23
2016	7,455,272	$7.46	$7.46	$1.50	$16.41
2017	7,546,113	$7.55	$7.55	$1.50	$16.59
2018	7,636,476	$7.64	$7.64	$1.50	$16.77
2019	7,726,254	$7.73	$7.73	$1.50	$16.95
2020	7,815,252	$7.82	$7.82	$1.50	$17.13

The costs for facility development and operation include all costs associated with planning, developing, constructing, and maintaining new recycling, composting, or other diversion facilities. The cost for additional recycling and compost facilities required by the additional diversion proposed by this mitigation option is assumed to be $80 per ton (annually) of additional waste recycled or composted.[46] The total annual cost of facility development and operation is displayed in Table X-17 below:

Table X-17: Incremental Facility Development and Operation Costs

[45] This spending could be employed in a myriad of ways based on local conditions and targets. This could be a combination of staff working directly with local businesses and residents; brochures and newsletters; or other tools and information resources. Research institute information provided by Snohomish County and Department of Ecology.

[46] The costs associated with planning, developing, constructing, and maintaining new recycling, composting, or other diversion facilities are quite speculative at such an early stage of consideration. The work group suggests $50 per ton as a starting point based on experiences in Pierce County. Based on CCS experience from other processes, $80 per ton appears to be a more reasonable cost estimate.

Year	Incremental Tons Composted	Incremental Tons Recycled	Compost Facility Cost ($MM)	Recycling Facility Cost ($MM)	Total Additional Facility Cost ($MM)
2008	-	-	$0.00	$0.00	$0.00
2009	87,941	87,233	$7.04	$6.98	$14.01
2010	175,882	174,465	$14.07	$13.96	$28.03
2011	263,823	261,698	$21.11	$20.94	$42.04
2012	351,764	348,931	$28.14	$27.91	$56.06
2013	469,635	465,851	$37.57	$37.27	$74.84
2014	587,505	582,772	$47.00	$46.62	$93.62
2015	705,375	699,693	$56.43	$55.98	$112.41
2016	823,246	816,614	$65.86	$65.33	$131.19
2017	941,116	933,535	$75.29	$74.68	$149.97
2018	1,058,986	1,050,456	$84.72	$84.04	$168.76
2019	1,176,857	1,167,376	$94.15	$93.39	$187.54
2020	1,294,727	1,284,297	$103.58	$102.74	$206.32

The cost savings accrued through the programs proposed in this mitigation option include net cost savings generated through source reduction, composting, and recycling. Source reduction leads to a direct cost savings, due to the avoided MSW collection and disposal cost. The cost savings accrued through increased composting includes the net cost of disposal at a compost facility (relative to landfill disposal), as well as the revenue generated through the sale of compost. The landfill collection disposal cost is assumed to escalate annually at a rate of 2.4%.[47] The cost of collection and disposal of compost is assumed to increase at the same rate as garbage (MSW). The value of compost in the State of Washington is assumed to be $12.00[48] per ton. The savings realized through recycling programs include the relative cost of sending the waste to a recycling facility, as opposed to a landfill. The cost savings from each diversion technique is calculated by multiplying the tons managed in each year by the difference between the net cost of traditional (landfill) management and alternative (recycling and composting) management. This difference is assumed to remain constant throughout the policy period, as the cost of management for each approach is assumed to increase at the same rate (2.4%).[49] Table X-18 and X-19 below display the per-ton collection and disposal costs for each waste management technique, as well as the estimated cost savings that result from the programs detailed in this mitigation option.

Table X-18: Per-ton Collection and Disposal Costs[50]

[47] Personal communication between S. Wamback and B. Strode; September 21, 2007.

[48] *Ibid*. This estimate is corroborated by "Compost Materials Market Assessment" by D. Long and A. Jackson. Report prepared on November 18, 2002 for Whatcom County Dairy Biogas Initiative.

[49] This assumption is conservative, as the AW TWG feels that it is likely that the cost of recycling and composting management could decrease with scale. However, the costs of these management techniques are heavily reliant upon strong markets for recycled material and compost. An influx of such material may inhibit increasing returns to scale.

[50] Collection and disposal costs for Pierce County. Personal communication between S. Wamback and B. Strode; September 21, 2007.

	Collection Cost ($/ton)	Disposal Cost ($/ton)	Net Cost ($/ton)
Landfill Disposal	$71.00	$99.00	$170.00
Recycling	$179.00	-$69.00	$110.00
Composting	$82.00	$60.00	$142.00

Table X-19: Incremental Cost Savings Due to Increased Source Reduction, Recycling, and Composting

Year	Incremental Tons Source Reduced	Landfill Net Cost Fee ($/ton)	Source Reduction Savings ($MM)	Compost Value ($/dry ton)	Recycling Savings ($MM)	Compost Savings ($MM)	Total Incremental Policy Savings ($MM)
2008	0	$170.00	$0.00	$12.00	$0.00	$0.00	$0.00
2009	91,252	$171.02	$15.61	$12.00	$5.23	$3.52	$24.36
2010	182,504	$172.05	$31.40	$12.00	$10.47	$7.04	$48.90
2011	273,757	$173.07	$47.38	$12.00	$15.70	$10.55	$73.63
2012	365,009	$174.10	$63.55	$12.00	$20.94	$14.07	$98.55
2013	451,829	$175.12	$79.12	$12.00	$27.95	$18.79	$125.86
2014	538,650	$176.14	$94.88	$12.00	$34.97	$23.50	$153.35
2015	625,470	$177.17	$110.81	$12.00	$41.98	$28.22	$181.01
2016	712,290	$178.19	$126.92	$12.00	$49.00	$32.93	$208.85
2017	799,111	$179.22	$143.21	$12.00	$56.01	$37.64	$236.87
2018	885,931	$180.24	$159.68	$12.00	$63.03	$42.36	$265.07
2019	972,751	$181.26	$176.32	$12.00	$70.04	$47.07	$293.44
2020	1,059,572	$182.29	$193.15	$12.00	$77.06	$51.79	$321.99

The discounted and levelized cost effectiveness of this mitigation option was determined by calculating the net present value (NPV) of the net cost of the mitigation option (the sum of planning, implementation, and facility development cost less cost savings). The estimated cumulative avoided emissions from this mitigation option are 29.21 $MMtCO_2e$. The NPV of the net option costs (shown in Table X-20) is estimated to be -$353 million, resulting in a cost effectiveness of -$12.10/ $MtCO_2e$.

Table X-20: Summary of Benefits and Costs

Year	Avoided Emissions (MMtCO2e)	Annualized Costs (MM$)	Discounted Costs (MM$)	Levelized & Discounted Cost Effectiveness
2008	0.00	$15.62	$15.62	
2009	0.32	$5.52	$5.26	
2010	0.65	-$4.78	-$4.34	
2011	0.97	-$15.28	-$13.20	
2012	1.30	-$25.98	-$21.37	
2013	1.73	-$34.31	-$26.88	
2014	2.16	-$42.82	-$31.95	
2015	2.60	-$51.52	-$36.61	
2016	3.03	-$60.39	-$40.87	
2017	3.46	-$69.44	-$44.76	

Year	Avoided Emissions (MMtCO2e)	Annualized Costs (MM$)	Discounted Costs (MM$)	Levelized & Discounted Cost Effectiveness
2018	3.90	-$78.68	-$48.30	
2019	4.33	-$88.09	-$51.50	
2020	4.76	-$97.68	-$54.39	
Totals	**29.21**	**-$547.83**	**-$353**	-$12.10

- **Key Assumptions:** In addition to the assumptions listed in the above documentation, it is important to note that this analysis applies only to recyclable/compostable waste materials that are potential inputs in the EPA Waste Reduction Model. Including all MSW in the analysis would likely increase the GHG reductions, assuming that all non-recyclable/compostable waste is source reduced at 15% as well. The analysis also considers only waste managed in the State of Washington. Uncontrolled waste management (i.e. backyard burning, illegal dumping) is not accounted for. Recent analysis shows that the statewide median fee is $73 per ton. Studies of waste prevention of non-hazardous manufactured goods (not home composting) have estimated that the avoided procurement benefits, per-ton of waste prevention are at least 10 times larger (and sometimes 50 – 100 times larger) than the avoided disposal benefits. This could push the "net net" well into cost savings territory.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:** Significant business and job creation will result from this policy option. According to the Institute for Local Self Reliance (ILSR), on a per-ton basis, *sorting and processing recyclables alone* sustain 10 times more jobs than landfilling or incineration.[51] Thus, an increasing shift towards recycling will help create and sustain additional jobs.

  Further, attaining the goals will spur: product and process design, research and engineering; manufacture of new products at existing and new businesses using recycled content; and refurbishment and repair for reuse. Job growth is even more dramatic in these areas, up to sixty times more employment on a per ton basis than landfilling.
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

Diverting Attention: The State of Washington has, for the past two decades, been a national leader in promoting recycling. As explained throughout, many efforts launched initially as solid waste management programs, are already underway in support of this policy option. Success of this policy option relies on these existing efforts not only being maintained and effectively executed, but expanded and protected against being cannibalized in the demand to fund and staff new programs. Already, in the public sector, many existing waste prevention/recycling staff are being pulled away to work on climate change, without any staff backfill. Existing staff and

[51] http://www.ilsr.org/recycling/recyclingmeansbusiness.html

funding needs to be supplemented and expanded, not diverted. As "climate change" work becomes prioritized, it needs to incorporate and expand existing activities that are key to its success, not replace those activities.

Measurement: Waste reduction activities are challenging and often difficult to measure. Even so, they are essential. Significant work will be needed to further define the specific actions necessary regarding waste reduction, as well as the other elements of this option, after its adoption and referral to the Governor.

Proscriptive Programs – Disposal Bans: Disposal bans may be necessary on the local and/or state level to achieve this policy option. While the significant benefits of diversion from landfilling are well documented, Washington has had a history of "voluntary only" approaches that rely on short-term pricing signals to spur participation. Using yardwaste as an example, many communities provide curbside or drop-off programs to collect yardwaste for composting. Most of these communities do not prohibit the placing of that yardwaste in a garbage container for disposal. Instead, through pricing structure, the community seeks to encourage the customer to compost rather than dispose.

In practice, however, such pricing structures account only for the internalized cost of collection and composting or disposal. Longer term, and external, costs and benefits are not as easily incorporated in current practices. Waste bans, however, are often proposed to stimulate the incorporation of those external costs. A decision to take disposal "off the table" means that it is not available at any price. Residents, businesses, and the larger marketplace are spurred to explore and accordingly price the remaining options. In addition to "reassigning" responsibility for previously externalized costs, directive approaches can set minimum performance standards for other options chosen, provide a level playing field among non-disposal options, and can establish bans that force material into the "climate friendly" private sector management options. In the ideal, this can all be done such that – after the government's initial "push" to impose the ban – market forces and private business initiatives prevail and without government developing burdensome rules or bloated bureaucracy. But it does require political stamina. Further, it requires the government to be more open in encouraging and supporting the market development of alternatives to traditional disposal. Most important, a ban requires a plan.

Business Outreach: This policy option envisions a different relationship between government actions and business actions that in the past. Local government recycling coordinators promoting more recycling to and by households will not achieve the goals of this policy option. Emphasis will need to shift and a new focus on business actions will be necessary. There is risk in that government entities may not have the knowledge or understanding to redirect their activities to working on business solutions rather than householder solutions.

Funding: To provide the greatest chance of success to this policy option, and to achieve the long-term environmental and economic benefits modeled, up-front funding should be dedicated to supplement existing funding and activities. Without additional funding we run the risk of cannibalizing existing, successful, programs to implement what's new.

At the same time, other critical climate change actions will also need funding. This policy option should not compete for funding against either existing programs or other GHG reduction measures. We need to develop and support a sustainable funding strategy focused on reducing the GHG impact of solid waste management.

The Department of Ecology recently estimated that solid waste collection, recycling, and disposal activities result in $1.8 billion in spending annually across the State of Washington.[52] A one-percent solid waste tax, similar to the tax that sunset in 2005 would raise $18 million in its first year. Such a tax would be reasonable only if launched with a directive that revenues be spent solely in support this policy option, including work with the private sector to vastly expand business activities in this area and work with the smaller and rural communities throughout the state that don't have the same access to recycling markets as enjoyed by larger and more urban communities. A further design necessity would be to impose this to fall more heavily on waste disposers and less heavily, or not at all, on waste reducers and recyclers. A tax on waste disposal would help account for the measured environmental impact of waste generation and disposal. Thus, not only would this be a revenue source, but an educational one as well, demonstrating yet another way in which recycling is more cost effective and environmentally advantageous than disposal or incineration.

Additional Benefits and Costs

This policy option, in the long run, will reduce work place, recycling/processing facility, consumer and environmental exposure to toxics and will reduce the release of toxics to the environment.

This policy option may lead to Washington businesses regaining competitiveness with businesses in Europe and Asia that may be outpacing U.S. businesses due to their focus on environmental attributes of product formulation and design. In some cases, these attributes are now required in order to sell into certain overseas markets, and this trend is expected to increase dramatically.

As well as creating economic development opportunities, this option protects existing manufacturing and business interests by providing recycled feedstocks during a time when virgin feedstocks are expected to become more expensive and more difficult to source.

Feasibility Issues

[Insert text here]

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

[52] Solid Waste Management Cost Flows in Washington State. Conducted for Washington State Department of Ecology and the Washington Solid Waste Advisory Committee. Prepared by Cascadia Consulting Group and Industrial Economics, Inc. September 2007.

AW-4. Agricultural Carbon Management

Mitigation Option Description

Vegetation and soils represent a substantial global pool of stored carbon at more than 2,000 Gt (billion tons) of carbon. Human activities have severely depleted carbon levels in these terrestrial pools releasing that carbon to the atmosphere. For instance, most agriculturally cultivated soils have lost at least 50% of the native carbon to the atmosphere. Changes in management in terrestrial systems can "restore" some of the lost carbon to soils and vegetation.

Agriculture carbon sequestration uses agricultural crops and acreage to store carbon in biomass and soils. Management functions that affect agricultural carbon storage include (1) biomass production / inputs, (2) residue management, and (3) soil disturbance. Increased biomass inputs (either through production, translocation, or residue management strategies) coupled with reduced disturbance will lead to increased soil carbon storage. Low biomass production, residue removal, and/or tillage reduce soil carbon storage. Existing, commercial management tools can affect each of these functions (positively and negatively).

In addition to human management activities, natural features such as precipitation patterns, soils, and temperature also affect the capacity of soils and vegetation to store carbon. The highly variable agro-climatic conditions in Washington State significantly impact the capacity of soils and vegetation to store carbon. Therefore, agricultural carbon management policies need to recognize variability across the landscape.

Mitigation Option Design

- **Goals:**
    - Increase carbon storage statewide in agricultural soils by implementation of proven and novel technologies, such as reduced tillage, cover cropping, increased perennial cropping, rotational grazing, managed grasslands, and alternatives to agricultural burning.
    - Increase diversion of organic residuals and wastes from all sources (including municipal wastes) for land application on agricultural soils.
    - Increase vegetative standing biomass in agriculture by 80,000 acres per year through the use of high biomass producing woody crops and perennial grasses sequestering.
    - Expand use of agricultural crops and residuals for bioproducts that sequester carbon (e.g. fiberboard from straw).
- **Timing:**

Soil carbon sequestration timing:

- Increase use of no-till / direct-seed farming practices in the dryland (high and intermediate rainfall zones) region of the state by an average of 100,000 acres / year between 2010 and 2020 for a total of at least 1 million acres (total no-till acres will be ~ 25% of dryland acres). 2020 goal level is roughly ~100% of estimated technical potential.
- Increase use of high-residue farming (i.e. cover crops, no-till, etc.) practices in the irrigated region of the state by 30,000 acres / year between 2010 and 2020 for a total of at least 300,000 acres (25% of irrigated acres). 2020 goal level approaches coverage of all corn and wheat acres in WA.
- Increase use of improved management on pasture / grassland / rangeland / Conservation Reserve Program lands throughout the state by an average of 300,000 acres / year between 2010 and 2020 for a total of at least 3 million acres (~35% of rangeland / pasture / grassland) by 2020. **Not quantified**
- Increase use of high-biomass perennial crops (hybrid poplar, switchgrass, etc.) to increase soil carbon storage by an average of 20,000 acres / year beginning in 2016, for a total of 80,000 acres by 2020. This practice initiates later due to the need to have commercially viable cellulosic energy conversion technologies / markets in place. See AW-2 for explanation of goal level.
- Consideration must be given for the maintenance (or offset) of existing soil carbon pools, such as orchards, riparian areas, and Conservation Reserve Program / Set-aside lands – most of which are affected by either markets or additional [state and federal] government programs. **Not quantified.** (This is covered to some degree by AW-7.)

Land Application of organic residuals:

- Re-direct the equivalent of an additional 0.8 million dry tons of raw organic residuals (equivalent to 1/3 of waste paper in Washington State) for land application to agriculture by 2020. These organic residuals could come in the form of raw, composted, anaerobically digested, or thermochemically converted materials. **Not quantified**

Standing Biomass:

- Increase use of high-biomass perennial crops (hybrid poplar, switchgrass, etc.) to increase above-ground, vegetative carbon storage by an average of 20,000 acres / year beginning in 2016, for a total of 80,000 acres by 2020. This practice initiates later due to the need to have commercially viable cellulosic energy conversion technologies / markets in place. Credit for the above ground carbon storage of perennial crops may need to be transferred if the biomass is converted to energy or materials. See AW-2 for explanation of goal level.
- Consideration must be given for the maintenance (or offset) of existing vegetative carbon pools, such as orchards, riparian areas, and Conservation Reserve Program / set-aside lands. **Non-quantified target.**

Use of biomass for bioproducts:

- Collection of crop residues / biomass crops from ~80,000 acres of high-yielding, irrigated land (approximately 30% of current irrigated wheat production) beginning ~2016 for sequestration in long-term materials storage (i.e. straw board, etc.). Note: Removal of crop residue will eliminate or reduce soil carbon sequestration – and therefore cannot be double credited and should be constrained to high-yielding farmland. Furthermore, removal of crop residues (and standing biomass) has implications for nutrient management. **Not quantified**

- **Coverage of parties:** Washington State University, Conservation Districts, USDA Natural Resource Conservation Service, Washington State Department of Agriculture, Washington State Department of Ecology, private sector
- **Other:** There is additional potential to increase carbon sequestration through agriculture practices beyond what is explicitly stated in the goals above. However, there is not enough information currently available to fully develop policies in these areas: replace CO2 emitting practices with CO2 neutral practices in agriculture (e.g. generation of CO2 in greenhouses; crop drying); optimize carbon-cropping for the state's diverse bioregional specifications that reduction GHG emissions, sequester carbon, and allows a cash crop for farmer (e.g. food, fuel, or carbon crop); increase conversion of dryland acreage to irrigated acreage (this will increase carbon sequestration but will rely upon more water that may not be available due to existing water rights and potential reduction in hydro power, snowpack, and rainfall); organic cropping systems (additional research is needed to compare location-specific organic and conventional cropping systems for carbon sequestration using life cycle assessment techniques that include, but are not limited to, tractor/farm vehicle hours, fuel usage, source of any nutrient and pesticides, hauling of nutrients and pesticides and respective application rates, and energy use from processing/conversion of crops for next stage use).

Implementation Mechanisms

- Complete a systematic inventory for baseline soil carbon levels in multiple crop / grazing / grassland systems across the state that can be utilized for establishing carbon market certification standards. (Much of the necessary data exists, but there are gaps).
- Fund the delivery of educational outreach and demonstrations *throughout the state* for proven and emerging direct-seeding, high residue farming systems and technologies, and organic production systems. Educational programs should address issues such as equipment options; crop rotation strategies; weed, disease and pest management; residue management strategies.
- Provide training for farmers, agency field staff, and crop consultants in the use of soil carbon measurement and accounting tools. These tools include "predictive management" tools (ie. soil / crop models like WSU's C-Farm or USDA's COMET VR) as well as "carbon validation" tools to document actual changes in soil carbon levels (ie. instrumentation).
- Support existing programs such as USDA's CRP, CSP, and EQIP to expand successful adoption of improved soil carbon management practices by producers. Expand programs that reduce risk and transition barriers (e.g. no-till drill rentals through conservation districts). Establish a revolving fund for the purchase of direct-seed / higher residue management technologies.

- Support research and commercialization of novel technologies that can enhance soil carbon sequestration such as perennial wheat, biochar, perennial grasses, and agriculturally-derived bioproducts.
- Fund educational programs on improved grazing management practices for ranchers. Enhance cost-share opportunities for improved grazing management practices (ie. EQIP cost-share for fencing / water to encourage rotational grazing). Encourage rangeland health monitoring programs (such as Land EKG™).

Related Policies/Programs in Place

- The Pacific Northwest Direct Seed Association
- PNW STEEP (Solutions To Environmental and Economic Problems)
- WSU Climate Friendly Farming Project
- WSU CropSyst Model and C-Farm Sub-model
- WSU / USDA ARS Research / Demonstration Farms (Cook Agronomy Farm, Palouse Conservation Farm, Wilke Direct-Seeding Project, Lind Experiment Station, Prosser Research & Extension Center, Paterson Research Farm, Pendleton Long-term Soil Carbon Experiment, etc.)
- WSU Extension
- WSU / U of I Conservation Tillage Specialist
- PM10 Project
- USDA farm programs – EQIP, CRP, CSP
- WA Ag Pilots Project
- WSU Center for Bioproducts and Bioenergy (operations not funded)
- WSU perennial wheat breeding program
- USDA-ARS agroecosystems project
- USDA-ARS/WSU bioenergy crops project
- EPA Region 10 Diesel Emissions Reduction Program (cost-share for direct-seed equipment)
- WSDA alternatives to agricultural burning program
- Conservation District programs – rental of direct seed drills
- King County and other land application of biosolids programs
- WDOE Beyond Waste program, Agricultural Burning Alternatives program
- **Northwest Natural Resource Group (WA), $200,000.00:** Promoting Small Landowner Access to Emerging Carbon Sequestration Markets through Forest Certification, Aggregation, and Market Development. http://www.nnrg.org/.
- **Washington Department of Natural Resources (DNR)**: DNR and WESTCARB produced an inventory of terrestrial carbon sequestration opportunities in Washington State.

Types(s) of GHG Reductions

[TWG has begun to provide input]

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2020 ($MMtCO_2e$):** 0.21, 1.12

- **Net Cost per $MtCO_2e$: -**$12.46
- **Data Sources:**

The data and methods utilized in the quantification of this option were largely provided by AW TWG experts. The primary sources of these data are studies in progress at the WSU Center for Sustaining Agriculture & Natural Resources and farmers in the state of Washington.

- **Quantification Methods:**

Increase use of no-till / direct-seed farming practices in the dryland

The change in carbon sequestered, based on direct seed, annual crop rotations is 417 lb C per acre per year.[53] Converting this carbon value into metric tons of CO_2e yields a reduction of 0.694 $MtCO_2e$ per acre per year.[54] This annual, per-acre value is multiplied by the number of acres expected to be treated in each year under this policy to yield the annual GHG reduction. The cumulative GHG reduction over the policy period is 3.82 $MMtCO_2e$.

Implementation costs of this option include an education and technical support program to inform farmers of the benefits (both economic and environmental) of direct seeding. This program is expected to cost $250,000 per year for the first 4 years of implementation.[55] This expense includes implementation programs for the entire state. The anticipated GHG emissions reduction and implementation cost of this policy option are shown in Table X-21.

Table X-21: GHG Emissions Reduction and Implementation Cost of No-till / Direct Seed Farming Practices in the Dryland Region of Washington State

Year	Acres in Program	GHG reduction (MMtCO2e)	Implementation Cost ($MM)	Discounted Costs ($MM)
2010	-	-	$0.25	$0.25
2011	100,000	0.07	$0.25	$0.24
2012	200,000	0.14	$0.25	$0.23
2013	300,000	0.21	$0.25	$0.22
2014	400,000	0.28	$0.00	$0.00
2015	500,000	0.35	$0.00	$0.00
2016	600,000	0.42	$0.00	$0.00
2017	700,000	0.49	$0.00	$0.00
2018	800,000	0.55	$0.00	$0.00
2019	900,000	0.62	$0.00	$0.00
2020	1,000,000	0.69	$0.00	$0.00
Total		3.82	$1.00	$0.93

Increase use of high-residue farming (i.e. cover crops, no-till, etc.) practices in the irrigated region

53 Bill Schillinger, Washington State University. Provided to B. Strode by C. Kruger via e-mail.

54 Conversion technique is as follows: 417 lb C * (1 ton C/2000 lb C) * (1 MtC/1.102 ton C) * (44 $MtCO_2e$/12MtC)

55 Personal Communication from C. Kruger to B. Strode on November 1, 2007.

This target applies to 300,000 acres of high-residue farmland in the irrigated region of Washington by 2020. Of these 300,000 acres, approximately 40,000 have the potential for mustard crops to be planted for fumigant purposes. The remainder will likely be comprised of high-residue field crops.

The change in annual carbon sequestered due to the implementation of cover crops with reduced tillage is 696 lb C per acre per year.[56] Converting above value to metric tons of CO_2e yields a reduction of 1.158 MtCO_2e per acre per year.[57] This annual per-acre sequestration rate is applied to both mustard and non-mustard cover crop situations.[58] The resulting cumulative GHG benefit attributed to high-residue farming practices in the irrigated region of Washington State is 1.91 MMtCO_2e.

The estimated net cost of non-mustard cover crops is estimated to be revenue neutral, similar to the dryland cover crop cost.[59] Mustard cover crops using green manure are estimated to incur a net cost savings of -$41 per acre. The net implementation cost of this policy – displayed in Table X-22 below – is $48.43 million NPV.

Table X-22: GHG Emissions Reduction and Implementation Cost of High-Residue Farming Practices in the Irrigated Region of Washington State

Year	Acres in Program (Hi-res fields)	Mustard Fumigant Acres	GHG reduction (MMtCO2e)	Cost of Direct Seed ($MM)	Discounted Costs ($MM)
2010	-	-	-	$0.00	$0.00
2011	30,000	4,000	0.03	-$1.23	-$1.17
2012	60,000	8,000	0.07	-$2.46	-$2.23
2013	90,000	12,000	0.10	-$3.69	-$3.19
2014	120,000	16,000	0.14	-$4.92	-$4.05
2015	150,000	20,000	0.17	-$6.15	-$4.82
2016	180,000	24,000	0.21	-$7.38	-$5.51
2017	210,000	28,000	0.24	-$8.61	-$6.12
2018	240,000	32,000	0.28	-$9.84	-$6.66
2019	270,000	36,000	0.31	-$11.07	-$7.14
2020	300,000	40,000	0.35	-$12.30	-$7.55
Total			1.91	-$67.65	-$48.43

Increase use of improved management on pasture / grassland / rangeland / Conservation Reserve Program lands throughout the state

The carbon benefits and implementation costs of this portion of the goal are too uncertain at the time to proceed with quantified analysis of this target. The range of GHG benefits is thought to be between 0.12 and 0.20 MtCO_2e per acre per year. These estimates are based on

[56] Andy McGuire, based on Dale Geis farm. Provided to B. Strode by C. Kruger via e-mail.

[57] Conversion technique is as follows: 696 lb C * (1 ton C/2000 lb C) * (1 MtC/1.102 ton C) * (44 MtCO_2e/12MtC)

[58] This assumption is based on text provided to CCS by Andy McGuire stating that another irrigated scenario, Williamson Farms, shows a similar soil carbon benefit based on strip tillage and rotational grazing.

[59] Personal communication. C. Kruger to B. Strode on November 8, 2007.

Chicago Climate Exchange (CCX) allowances for rangeland management.[60] However, having no documentation regarding the development of these factors, the TWG feels that the uncertainty is too great to adopt them as reasonable estimates for carbon storage in Washington pasturelands, grasslands, rangelands, and CRP-lands. Additionally, implementation cost estimates currently available rely on assumptions that likely will not capture the entire revenue saving potential of this target.

Increase use of high-biomass perennial crops (hybrid poplar, switchgrass, etc.) to increase soil carbon storage

This option was quantified using switchgrass as the sole perennial crop, as hybrid poplar soil sequestration values were not readily available. The increase soil organic carbon derived from carbon in Kanlow switchgrass is 2,637 kgC/ha.[61] The net GHG benefit from switchgrass-derived carbon sequestration in soil is 3.91 $MtCO_2e$.[62] As the typical rotation of swichgrass is greater than the policy period considered here, it is assumed that soil carbon only accumulates for new acres entering high-biomass production. Therefore, the net GHG benefit is only applied to 20,000 acres per year for four years. The cumulative GHG benefit - as displayed in Table X-23 - for this target is 0.31 $MMtCO_2e$.

The net cost of this option is the difference between the cost of switchgrass production and revenue derived from the sale of switchgrass. Currently, information on the economics of switchgrass is limited. The current market value of switchgrass is estimated to be $140 per ton. This estimate is likely low, as future markets for switchgrass as an ethanol feedstock are not accounted for. While the cost of switchgrass production was not available, the production cost of alfalfa hay was used as a reasonable proxy. The cost of alfalfa production is $1,005 per acre per year, including the establishment costs, annual harvesting costs, nutrient costs, and irrigation costs. Based on the expected revenue and cost of production, this target is expected to achieve a net cost savings of -$27.74 million NPV (see Table X-23).

Table X-23: GHG Emissions Reduction and Implementation Cost of High-Biomass Crop Production for Soil Carbon Sequestration in Washington State

Year	Acres in Program	New Acres Accumulating C	GHG Benefit (MMtCO2e)	Production Cost ($MM)	Revenue ($MM)	Net Cost ($MM)	Discounted Costs ($MM)
2010	-	-	-	$0.00	$0.00	$0.00	$0.00
2011	-	-	-	$0.00	$0.00	$0.00	$0.00
2012	-	-	-	$0.00	$0.00	$0.00	$0.00
2013	-	-	-	$0.00	$0.00	$0.00	$0.00
2014	-	-	-	$0.00	$0.00	$0.00	$0.00
2015	-	-	-	$0.00	$0.00	$0.00	$0.00
2016	-	-	-	$0.00	$0.00	$0.00	$0.00
2017	20,000	20,000	0.078	$20.10	$24.40	-$4.30	-$3.05
2018	40,000	20,000	0.078	$40.20	$48.79	-$8.59	-$5.82

[60] Charlie Orchard (land EKG) Midpoint of CCX values assigned to rangeland entered into proper managmenet, not degraded vs. degraded

[61] Collins, H.P., S. Fransen, and J. L. Smith. (2007, Draft in Progress). "Carbon Sequestration under Irrigated Switchgrass (*Panicum virgatum)* Production." Provided to CCS by C. Kruger via e-mail.

[62] 3.91 $MtCO_2e$ = 2637 kgC/ha * 1 MtC/1000 kgC *1 ha/2.47 acres * (44 $MtCO_2e$/12MtC)

Year	Acres in Program	New Acres Accumulating C	GHG Benefit (MMtCO2e)	Production Cost ($MM)	Revenue ($MM)	Net Cost ($MM)	Discounted Costs ($MM)
2019	60,000	20,000	0.078	$60.30	$73.19	-$12.89	-$8.31
2020	80,000	20,000	0.078	$80.40	$97.59	-$17.19	-$10.55
Total			0.313	$201.00	$243.97	-$42.97	-$27.74

Re-direct organic residuals for land application to agriculture

The TWG considers the best available quantification methods for this option to be too uncertain to report in this document. The approach that had been developed was to use waste paper as a proxy for organic residual land application. This is not an acceptable proxy, as the likely residual to be used for land application is a bi-product of anaerobic digestion (such as in AW-1). However, the impact on soil carbon levels (as well as other nutrients) cannot be modeled with sufficient confidence by CCS or TWG experts at this time.

Increase use of high-biomass perennial crops (hybrid poplar, switchgrass, etc.) to increase above-ground, vegetative carbon storage

This target will not be quantified, as a result of direct overlap with AW-2. Should these 80,000 acres be used as feedstock for cellulosic ethanol, the vegetative carbon storage would be mostly combusted as motor fuel. Although there might be some above-ground carbon storage beyond what is converted into cellulosic ethanol, it is not known what this carbon storage value might be. Also, cost estimates are calculated as a part of AW-2, as well as the "high-biomass perennial crops to increase soil carbon storage" target above, and therefore need not be counted here.

Collection of crop residues / biomass crops from ~80,000 acres of high-yielding, irrigated land for bio-products production.

While current methods have been able to estimate the potential short-term carbon storage in straw-based bio-products, the modeling for the long-term decomposition of such products is not available in the short-term. Therefore, the TWG is reluctant to put forth final GHG emissions reduction or cost effectiveness estimates on this target.

Total GHG Reduction and Cost Effectiveness

The total GHG emissions reduction potential across all quantified targets is 6.04 $MMtCO_2e$ through 2020. These targets are projected to lead to a net cost savings of -$75.23 million NPV and a levelized cost effectiveness of $12.46/$MtCO_2e$. Annual results are reported in Table X-24:

Table X-24: GHG Emissions Reduction Potential and Cost Effectiveness for All Targets in AW-4

Year	GHG Reduction (MMtCO2e)	Net Cost of Programs ($MM)	Discounted Costs ($MM)	Discounted / Levelized Cost Effectiveness ($/MtCO2e)
2010	-	$0.25	$0.25	
2011	0.10	-$0.98	-$0.93	
2012	0.21	-$2.21	-$2.00	
2013	0.31	-$3.44	-$2.97	

Year	GHG Reduction (MMtCO2e)	Net Cost of Programs ($MM)	Discounted Costs ($MM)	Discounted / Levelized Cost Effectiveness ($/MtCO2e)
2014	0.42	-$4.92	-$4.05	
2015	0.52	-$6.15	-$4.82	
2016	0.62	-$7.38	-$5.51	
2017	0.81	-$12.91	-$9.17	
2018	0.91	-$18.43	-$12.48	
2019	1.02	-$23.96	-$15.45	
2020	1.12	-$29.49	-$18.10	
Totals	**6.04**	**($109.62)**	**($75.23)**	**(12.46)**

– **Key Assumptions:**

The key assumptions, aside from those stated in the text above, are as follows: 1) production cost estimates are based on best available information on the costs an "average" Washington farmer would expect to incur. Potential production costs may be lower than stated above; 2) the crops considered in this analysis – and the land they are grown on – are very homogenous. The state of Washington is home to a great variety of agricultural outputs, many of which might have different costs and benefits from those projected by this analysis; 3) future markets for crops are not reliably forecasted and therefore not considered in this analysis. Changes in revenue available to farmers may alter the economics of this option dramatically.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:** Bioproducts can offset use of fossil fuel feedstocks. Gasification to make biochar is a source of bioenergy. Direct seeding reduces on-farm energy use by decreasing tractor fuel consumption.

Key Uncertainties

- Washington State lags the nation, and the US lags many other nations, in adoption of direct seed systems. Some of this is due to production risks where continued research may help resolve current problems. Another issue is investment risk in purchasing the new equipment needed.
- Biochar is untested in the diversity of soils in the state, so it is unknown whether benefits described elsewhere will occur here. Production of biochar is dependent on availability and deployment of gasification technology, for which there is no clear standard or leader at this time.
- The price of transport fuel will dictate the economic feasibility of moving large volumes of agricultural residuals to the place of beneficial use.
- How will increasing temperatures counteract our efforts to store soil C?

- There are still many uncertainties about the impact of specific farming practices on GHG. For example, the recent article by Hamilton et al. (2007) illustrates the uncertainty as to whether agricultural liming is a net source or sink for CO2, with significant implications for the GHG impact of various farming systems.

Additional Benefits and Costs

- Direct seed can lead to increased water infiltration and reduced sandblasting of crops, increasing profits. It can also protect water quality from sediment and agrichemicals, and air quality from dust. Initially direct seed may cost more due to increased fertilizer and pesticide use, and higher potential for crop loss.
- Use of organic amendments for fertilizer and soil quality helps position a farm for certified organic production where there are currently substantial price premiums for many crops grown in the state. There is currently a shortage of organic hay, and growing this crop would provide a financial boost to growers and support the use of perennial crops that can sequester carbon.
- A new strawboard process from WSU could open the market for this product. Excess straw, some of which is currently burned, could go to this product and be sequestered for 20-50 yr (whatever one uses for the life of a building).

Feasibility Issues

- The uniqueness of the state's agricultural diversity and variability must be considered in any agriculture carbon policy. Any such policy must be based off of sound research of our state's agricultural land and crops, and consider bio-regional differences in any recommendations.
- Overall sustainability is an important criterion for considering trade offs in benefits. For example, irrigating previous dryland acres for the purpose of sequestrating carbon will require using more water
- More investment is needed to develop carbon storage validation tools for both policy and carbon market use. Without such tools, viable agriculture mitigation efforts will be difficult.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AW-5. Agricultural Nutrient Management

Mitigation Option Description

Agricultural nutrients are critical to the sustainable production of food, fiber and energy – and in many cases a primary cost of agricultural production. Nutrients are derived from many sources including fossil fuels, mined materials and biological materials / fixation. Poor nutrient use efficiencies in agricultural systems, the consequence of biological, technological and management factors, lead to considerable losses of nutrients (especially nitrogen) to the environment. Agriculture is the primary source of nitrous oxide (N_2O) emissions in the US, a greenhouse gas > 300 times as potent as CO_2. In addition to N_2O emissions, reactive forms of nitrogen are lost to the environment as nitrates and ammonia. While these losses have negative environmental ramifications, they also represent significant financial consequences for farmers. Improving on-farm nutrient use efficiencies; alternative, biological sources of nutrients, and enhanced recovery / relocation of nutrients will substantially reduce ag-related greenhouse gas emissions, improved economic returns for farmers, and reduced fossil energy use.

This option seeks to reduce GHG emissions from nutrient use by implementing improved management on farms, which will lead to more efficient use of fertilizers. This more efficient use could lower N_2O emissions from crop soils and leaching, as well as emissions associated with the production, transport, and application of commercial fertilizers. *[Note the linkage to one of the goals under AW-1, where the products from anaerobic digester projects are to be targeted for use to offset commercial fertilizer use]*

Mitigation Option Design

- **Goals:**
    - Reduce CO_2 emissions associated with excess applications of natural gas derived nitrogen and mined phosphorous through implementation of farm nutrient management plans and soil testing by 10% statewide.
    - Reduce N_2O emissions and use of natural gas derived nitrogen by an average of 10% per acre in the dryland production regions through application of *precision agriculture* technologies which reduce both total N applied as well as reduced N_2O evolution from soils. Goal level based on the average technical potential for the region.
    - Reduce N_2O emissions and use of natural gas derived nitrogen and mined phosphorous through recovery of 50% of the nitrogen and phosphorous from 25% of existing sources of nutrient concentrated biomass, such as manure, by 2020. Linked to implementation of AW-1, and based on an inventory of wet biomass streams.

- Reduce CO_2 emissions associated with the use of natural gas derived nitrogen and mined phosphorous by redirecting 25% of Washington inventoried biomass-based nutrients to farms by 2020.
- Reduce CO_2 emissions by 20% through displacement of natural gas derived nitrogen with the use of biologically fixed nitrogen practices on 250,000 acres by 2020.

- **Timing:**
  - Implement farm nutrient management planning and soil testing state-wide by 2012, reduce excess nutrient applications by 10% of total nitrogen applied by 2020.
  - Increase the number of acres using *precision nitrogen management* technologies by 250,000 acres per year until 2020 (targeting the dryland production region)
  - Redirect an additional 2.5% per year of biomass-derived nutrients to farms until 2020.
- **Coverage of parties:** WSU, WSDA, Ecology, Conservation Districts, EPA, Private Sector
- **Other:**

Implementation Mechanisms

- Complete a geographic inventory of ag nutrient demand for Washington that can be overlayed with a geographic inventory of biological nutrient sources (effort underway between Department of Ecology and WSU).
- Implement requirements for Comprehensive Nutrient Management Plans for all farms (currently only required of CAFOs), including mandatory soil testing.
- Provide cost-share funding and/or revolving loans for the purchase and installation of precision nitrogen management technologies.
- Fund research, development *and* commercialization of biological nutrient recovery technologies, use of nitrogen fixing plants and microbes, and the impact of using biological materials as a source for plant nutrition (ie. pathogenic concerns, etc.).
- Fund the delivery of educational outreach, demonstrations and training *throughout the state* for precision nitrogen management technology, farm nutrient management planning, organic production systems, use of nitrogen-fixing cover-crops, integration of animals in cropping systems, and composting.

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

CO_2: Reducing the amount of nitrogen fertilizer needed will reduce CO_2 emissions that result from the fertilizer manufacturing process.

N_2O: Increasing the efficiency of nitrogen fertilizer application is expected to reduce N_2O emissions released from application, as well as the manufacturing process.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2020 ($MMtCO_2e$):** 0.03, 0.16
- **Net Cost per $MtCO_2e$: -**$2.48
- **Data Sources:**

Data used to support the quantification of this option includes the following sources (references cited in-text): personal communication from AW TWG members and other experts of the agriculture sector to CCS; a fact sheet from climateandfarming.orgl; and a survey of nitrogen fertilizer production emissions conducted in cooperation with the International Energy Agency.

- **Quantification Methods:**

Precision Nutrient Management (PNM)

The baseline application rate is assumed to be 100 lbs/acre average across the field crops (this value may be slightly high for wheat on average, really low for higher value veg crops).[63] N savings from PNM average 10%.[64] 1.25% of N applied each year released as N_2O.[65] The resulting direct net GHG benefit per acre of PNM is 0.028 $MtCO_2e$ per year.[66]

Indirect benefits in the form of reduced emissions from the production of synthetic fertilizer from fossil fuels are also considered. Based on Wood and Cowie (2004), the average emission factor from synthetic fertilizer production is 6,200 gCO_2e/kgN.[67] The resulting GHG benefit related to averted production of synthetic fertilizer is 0.028 $MtCO_2e$/ac/yr.[68]

The resulting projected GHG benefit from PNM is 0.77 $MMtCO_2e$ through 2020 (see Table X-25).

The value of fertilizer that is saved as a result of this process is $0.50/lb N.[69] Equipment such as GPS-driven nutrient application systems are needed to achieve this target. Based on an investment of $30,000 for a 3,000 acre farm in PNM equipment ($1.30/acre if the cost is

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63 Personal communication from C. Kruger to B. Strode via e-mail on October 19, 2007.

64 *Ibid*.

65 Duxbury, J. M. (Year Unkown, but after 2005). "Soil Carbon Sequestration and Nitrogen Management for Greenhouse Gas Mitigation." Accessed on November 5, 2007 from: http://climateandfarming.org/pdfs/FactSheets/IV.2Soil.pdf.

66 0.028 $MtCO_2e$/yr = 100 lbs N/acre * 10% * 1.25% * 1 ton N/2000 lbs N * 1 MtN / 1.102 ton N * 1.57 MtN_2O/1 MtN * 310 $MtCO_2e$/ 1 MtN_2O.

67 Wood, S. and A. Cowie. (2004). "A Review of Greenhouse Gas Emission Factors for Fertiliser Production." *For IEA Bioenergy Task 38*. Accessed on November 7, 2007 from; http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer%20Production_July2004.pdf.

68 0.028 $MtCO_2e$/ac/yr = 100 lbs N/acre * 10% * 1 ton N/2000 lbs N * 1 MtN / 1.102 ton N * 6,200 gCO_2e/kgN * 1000 kgN / 1 MtN * 1 $MtCO_2e$ / 1,000,000 gCO_2e.

69 Personal communication from C. Kruger to B. Strode via e-mail on October 19, 2007.

annualized over 10 years at 5% interest), the net cost per acre is a savings of \$3.70/acre. The cumulative, non-discounted cost of PNM is -\$50.94 million (see Table X-26).

Cover-Cropping

Assume that 100,000 acres of cover cropping can be achieved through this program. These acres will likely be tree fruit crops, under irrigated conditions and in, as here is a tradeoff between cover cropping for N and water for production in the dryland region of Washington. With 60 pounds of N fixed per acre and 50% of that available to the subsequent crop, an estimated 30 lb/acre of synthetic N is saved.[70] Using the same conversion practices from the PNM methodology (see footnotes), the net GHG benefit per acre is found to be 0.083 $MtCO_2e$/ac/year.

As with PNM, cover-cropping reduces the amount of synthetic nitrogen fertilizer that must be applied. The same emission factor and methodology were used to derive the per-acre GHG benefit of averted fertilizer production. This value is 0.084 $MtCO_2e$/ac/yr. The cumulative emissions reduction resulting from this cover-cropping target is 0.09 $MMtCO_2e$ (see Table X-25).

The net cost of cover cropping fruit orchards is estimated to be \$80 per acre. The incremental production cost associated with cover-cropping is \$95/ac/yr. The cost savings of averted nitrogen fertilizer applications is estimated to be \$15/ac/yr.[71] The cumulative, non-discounted cost of cover-cropping the targeted fruit orchards in Washington is \$44.00 million (see Table X-26).

Biomass-nutrient applications

The TWG considers the best available quantification methods for this option to be too uncertain to report in this document. The approach that had been developed was to use waste paper as a proxy for organic residual land application. This is not an acceptable proxy, as the likely residual to be used for land application is a bi-product of anaerobic digestion (such as in AW-1). However, the impact on nitrous oxide emissions cannot be modeled with sufficient confidence by CCS or TWG experts, at this time.

Total GHG Reduction and Cost Effectiveness

The projected cumulative GHG emissions reduction benefit of the quantified targets in AW-5 is 0.86 $MMtCO_2e$ through 2020. The total estimated net cost of this policy option is -\$2.13 million NPV. The cost effectiveness is -\$2.48/$MtCO_2e$.

Table X-25: GHG Emissions Reduction Benefits of AW-5

Year	Precision N Acres	GHG Benefit from Precision N (MMtCO2e)	Cover Crop Acres	GHG Benefit from Cover Crop (MMtCO2e)	Total GHG Benefit (MMtCO2e)
2010	-	-	-	-	-
2011	250,000	0.01	10,000	0.002	0.02

[70] Input from David Granastein. Provided to B. Strode by C. Kruger via e-mail. Suggusted website for Mr. Granastein: http://organic.tfrec.wsu.edu/OrganicIFP/OrchardFloorManagement/Index.html

[71] \$15/acre = \$0.50 / lbN * (60 lbN/acre – 30 lbN/acre)

2012	500,000	0.03	20,000	0.003	0.03
2013	750,000	0.04	30,000	0.005	0.05
2014	1,000,000	0.06	40,000	0.007	0.06
2015	1,250,000	0.07	50,000	0.008	0.08
2016	1,500,000	0.08	60,000	0.010	0.09
2017	1,750,000	0.10	70,000	0.012	0.11
2018	2,000,000	0.11	80,000	0.013	0.12
2019	2,250,000	0.13	90,000	0.015	0.14
2020	2,500,000	0.14	100,000	0.017	0.16
Totals		0.77		0.09	0.86

Table X-26: Net Cost Effectiveness of AW-5

Year	GHG Benefit (MMtCO2e)	Net Cost PNM (MM$)	Net Cost Cover Crop (MM$)	Program Implementation Costs (MM$)	Net Policy Cost (MM$)	Discounted Cost (MM$)	Discounted / Levelized CE
2010	-	$0.00	$0.00	$0.00	$0.00	$0.00	
2011	0.02	-$0.93	$0.80	$0.33	$0.21	$0.20	
2012	0.03	-$1.85	$1.60	$0.34	$0.09	$0.08	
2013	0.05	-$2.78	$2.40	$0.35	-$0.03	-$0.02	
2014	0.06	-$3.70	$3.20	$0.36	-$0.15	-$0.12	
2015	0.08	-$4.63	$4.00	$0.37	-$0.26	-$0.21	
2016	0.09	-$5.56	$4.80	$0.38	-$0.38	-$0.29	
2017	0.11	-$6.48	$5.60	$0.38	-$0.50	-$0.36	
2018	0.12	-$7.41	$6.40	$0.39	-$0.62	-$0.42	
2019	0.14	-$8.34	$7.20	$0.40	-$0.74	-$0.47	
2020	0.16	-$9.26	$8.00	$0.41	-$0.85	-$0.52	
Totals	0.86	-$50.94	$44.00	$3.71	-$3.23	-$2.13	-$2.48

- **Key Assumptions:**

The key assumptions used to complete the analysis of this option – other than those stated in the text – are as follows: 1) it is assumed that all synthetic fertilizer applications averted by this option are fossil-fuel derived; 2) it is assumed that the cost of $30,000 for PNM on a 3,000 acre farm leads to a $10/acre cost that is applicable to all farms. This is not likely the case, as larger farms will pay a smaller cost per acre and smaller farms will pay a larger cost.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AW-6. Reductions In On-Farm Energy Use and Improvements in Energy Efficiency

Mitigation Option Description

It has been estimated that the US food system as a whole (i.e. seed to dinner table) consumes as much as 1/5th of the US energy supply. Furthermore, the food system is one of the few sectors that uses every type of energy product, from electricity and thermal energy to liquid fuel to refined fertilizer, chemical, and material products derived from fossil fuels. A large fraction of this energy consumption occurs on-farm through the material and fuel consumption needed to produce crops and livestock.

The policy aims to reduce on-farm energy use and associated GHG emissions through the application of energy efficiency measures or on-farm energy projects.

Mitigation Option Design

- **Goals:**
    - Reduce liquid fuel consumption by an average of 25% per acre over 1 million acres in the dryland region and 300,000 acres of irrigated cropland through adoption of equipment, technologies and cropping system practices that reduce the number of "tractor trips" across a field. Based on targets set in AW-4 for direct seed and high residue farming)
    - Improve electrical and thermal energy use efficiencies in agricultural facilities by 10%.
    - Reduce use of irrigation-related energy use through adoption of water use efficiency technologies *and* improved cropping system practices by 10%. Studies show that converting to direct seed practices reduces water use by 10%. This target is linked to direct seed goals set in AW-4.
    - Substitute "on-farm" renewable energy technologies (solar, wind, geothermal) for fossil-fuel derived electricity and thermal energy products by an estimated 10MW capacity by 2020.
- **Timing:**
    - Reduce liquid fuel consumption: increase use of no-till / direct-seed farming practices in the dryland (high and intermediate rainfall zones) region of the state by an average of 100,000 acres / year between 2010 and 2020 for a total of at least 1 million acres (total no-till acres will be ~ 25% of dryland acres).
    - Reduce liquid fuel consumption *and* irrigation-related energy use: increase use of high-residue farming (i.e. cover crops, no-till, etc.) practices in the irrigated region of the state by 30,000 acres / year between 2010 and 2020 for a total of at least 300,000 acres (25% of irrigated acres).

- **Coverage of parties:** WSDA, WSU College of Agriculture, Human and Natural Resources Sciences, WSU Extension Energy Program, Conservation Districts, Private Sector
- **Other:** *There is a significant amount of overlap between energy efficiency goals and goals in the ag carbon and ag nutrient management straw proposals. The same practices that can be employed for improving soil carbon sequestration or reducing nutrient use can be used to reduce ag energy use.

Implementation Mechanisms

- Complete an agriculture and food system energy use inventory for Washington state and identify key opportunities for systemic improvements in energy use.
- Fund the delivery of educational outreach and demonstrations *throughout the state* for proven and emerging direct-seeding / high residue farming systems and technologies. Educational programs should address issues such as equipment options; crop rotation strategies; weed, disease and pest management; residue management strategies.
- Support existing programs such as USDA's CRP, CSP, and EQIP to expand successful adoption of improved soil carbon management practices by producers. Expand programs that reduce risk and transition barriers (e.g. no-till drill rentals through conservation districts). Establish a revolving fund for the purchase of direct-seed / higher residue management technologies.

Related Policies/Programs in Place

TBD

Types(s) of GHG Reductions

CO_2: GHG reductions that occur as a result of a decline in on-farm energy use are largely comprised of CO_2, which is the byproduct of combustion of diesel fuel to run farm equipment, such as tractors, and the indirect byproduct of the generation of electricity that is used for irrigation pumps, lighting, food processing, and other agricultural processes.

CH_4 and N_2O: These gases are also emitted through the different forms of combustion that create energy for use on farms. The greenhouse effects of these gases are normalized and included in the GHG reduction potential calculations that are expressed as units of CO_2e (carbon dioxide equivalent).

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2020 ($MMtCO_2e$):** 0.01, 0.06
- **Net Cost per $MtCO_2e$: -**$23.37
- **Data Sources:**

Key data sources for this analysis are Andy McGuire, the WSU Ag Systems Specialist for Grant/Adams Counties. Other data sources were the USDA Farm and Irrigation Survey, Mark Scheffels, TWG input, and data and assumptions from the Washington and Colorado Energy Supply TWGs.

- **Quantification Methods:**

Dryland fuel reduction

Based on a comparison of the fuel input of direct seed annual crop production and conventional annual crop production conducted by Mark Sheffels, assume 2.15 gallons of diesel fuel saved per acre under direct seed management.[72] The EPA diesel fuel emission factor is 10.1 kg CO_2 per gallon, which converts to 0.0101 $MtCO_2e$ reduced per gallon of fuel saved.[73] The resulting GHG savings per acre is 0.0217 $MtCO_2e$ per acre. The cumulative GHG emissions reduction attributed to direct seeding on the dryland region of Washington state is 0.12 $MMtCO_2e$ through 2020 (see Table X-27).

The cost of the direct seeding program in this target – under consideration in AW-6 – is included in the analysis of AW-4. The cost savings resulting from decreased fuel consumption is calculated here and attributed to AW-6. The cost savings resulting from reduced fuel consumption is calculated based on 138,691 Btu/gal energy content,[74] and a levelized 2008-2020 diesel cost of $9.50/MMBtu.[75] At a savings of 2.15 gallons per acre, the per-acre cost savings is -$2.83 per acre. The total cost savings of this target through 2020 is -$11.15 million NPV (see Table X-27).

Table X-27: GHG Emissions Reduction and Cost Effectiveness Attributed to Fuel Reduction Resulting From Direct Seed Farming in the Dryland Region

Year	NT/DS Acres	GHG Benefit (MMtCO2e)	Cost Savings ($MM)	Discounted Cost Savings ($MM)
2010	-	-	$0.00	$0.00
2011	100,000	0.00	$0.28	-$0.27
2012	200,000	0.00	$0.57	-$0.51
2013	300,000	0.01	$0.85	-$0.73
2014	400,000	0.01	$1.13	-$0.93
2015	500,000	0.01	$1.42	-$1.11
2016	600,000	0.01	$1.70	-$1.27
2017	700,000	0.02	$1.98	-$1.41
2018	800,000	0.02	$2.27	-$1.53
2019	900,000	0.02	$2.55	-$1.64

[72] Mark Sheffels. 85c Catapillar Challenger tractor for all operations except spraying. Spraying is done with a 2670 Case wheel tractor. Difference between 5.25 gal/acre for conventional annual crop production and 3.10 gal/acre for direct seed annual crop production.

[73] based on 10.1 kg/gal from EPA: http://www.epa.gov/otaq/climate/420f05001.htm

[74] http://www.eia.doe.gov/kids/energyfacts/science/energy_calculator.html

[75] Levelized costs, 2008 to 2020. US DOE/EIA data are not available for WA or PADD IV. US DOE/EIA data provide US average wholesale for heating oil of $1.72 per gallon in 2005/2006 heating season. This cost does not include fuel taxes. An appendix to the 2006 Annual Energy Outlook by USDOE/EIA (see http://www.eia.doe.gov/oiaf/aeo/pdf/appendixes.pdf) lists an energy content for distillate oil of 5.799 MMBtu/bbl, or 0.138 MMBtu/gallon. Cost computed used for 2006 price, which is escalated using the trends from AEO2006 distillate oil prices for the Pacific region (see "AEO2006 worksheet in this workbook").

Year	NT/DS Acres	GHG Benefit (MMtCO2e)	Cost Savings ($MM)	Discounted Cost Savings ($MM)
2020	1,000,000	0.02	$2.83	-$1.74
Total		0.12	$15.58	-$11.15

Irrigated cropland fuel reduction (includes irrigation efficiency)

For irrigated cropland in Washington, the value used for gallons of fuel saved per acre is 2.48 gal/acre.[76] In addition to fuel savings, implementing a cover crop system on irrigated land can save 3 acre-inches of water per year.[77] From a University of North Dakota Study, the calculated energy usage of irrigation equipment is 27.78 kWh/ac-in, for an electricity savings of 83.33 kWh/acre.[78] According to the 2003 USDA Farm and Ranch Irrigation Survey, most irrigation pumping in WA is powered by electricity.[79] Therefore, electricity is the only energy input considered in this analysis. The electricity emission factor used is 0.0005 $MtCO_2e$/kWh.[80] The GHG savings per acre – displayed in Table X-28 – from both reduced fuel and electricity use is 0.07 $MtCO_2e$/acre and the cumulative GHG emissions reduction is 0.11 $MMtCO_2e$.

Using the same calculation methods as the dryland fuel reduction calculation, the cost savings attributed to averted diesel consumption is -$3.27 per acre. The cost savings calculations attributed to reductions in irritation include both the value of electricity and water. The cost of avoided electricity is $0.064/kWh[81] and the cost per acre-inch of water is about $3.00, for a cost savings of $9.00 per acre.[82] The total cost savings per-acre, including the averted costs associated with diesel fuel, electricity, and water is -$17.77 per acre. The cost savings associated with this target have an NPV of -$20.99 million (see Table X-28).

Table X-28: GHG Emissions Reduction and Cost Effectiveness Attributed to Fuel Reduction and Averted Irrigation from High-Residue Farming in the Irrigated Region of Washington State

Year	CC/NT Acres	GHG Benefit (MMtCO2e)	Cost Savings ($MM)	Discounted Cost Savings (MMtCO2e)

[76] http://cff.wsu.edu/publications/posters/economics%20of%20reduced%20till%20potatoes.pdf

[77] Andy McGuire, WSU Ag Systems Specialist for Grant/Adams Counties. Input provided by C. Kruger to B. Strode via e-mail.

[78] Derived from: http://www.ext.nodak.edu/extnews/snouts/spout215.htm ($0.09/kWh electricity leads to $2.50 per acre inch under average depth and pressure)

[79] US Dept. of Agriculture; National Agricultural Statistics Service. *2003 Farm and Ranch Irrigation Survey*. Table 20: Energy Expenses for On-Farm Pumping of Irrigation Water by Water Source and Type of Energy: 2003 and 1998. Accessed on August 29 from: http://www.agcensus.usda.gov/Publications/2002/FRIS/tables/fris03_20.pdf.

[80] As used in Energy Supply analysis as of 9/20/07 for "small reductions." Can be considered an initial estimate.

[81] Estimate derived from MWPCC data from RTF analysis, same source as marginal CO_2 emission rate for electricity reductions. This is the simple average (not levelized value) of the marginal dispatch costs for 2010, 2015, and 2020.

[82] Andy McGuire, WSU Ag Systems Specialist for Grant/Adams Counties. Input provided by C. Kruger to B. Strode via e-mail.

Year	CC/NT Acres	GHG Benefit (MMtCO2e)	Cost Savings ($MM)	Discounted Cost Savings (MMtCO2e)
2010	-	-	$0.00	$0.00
2011	30,000	0.00	-$0.53	-$0.51
2012	60,000	0.00	-$1.07	-$0.97
2013	90,000	0.01	-$1.60	-$1.38
2014	120,000	0.01	-$2.13	-$1.75
2015	150,000	0.01	-$2.67	-$2.09
2016	180,000	0.01	-$3.20	-$2.39
2017	210,000	0.01	-$3.73	-$2.65
2018	240,000	0.02	-$4.26	-$2.89
2019	270,000	0.02	-$4.80	-$3.09
2020	300,000	0.02	-$5.33	-$3.27
Total		0.11	-$29.32	-$20.99

Improve electrical and thermal energy use efficiencies in agriculture facilities

Upon quantification of the GHG benefits of this target, it was discovered that the goal of increasing the efficiency of thermal and electrical energy use of agricultural facilities by 10% did not yield a significant GHG benefit. Best available information shows that heating and lighting compose 17% of total on-farm energy use. Of this 17%, 69% is attributed to natural gas, 30% to electricity, and 1% to other. The total on-farm energy use in Washington was calculated based on the national share of on-farm energy use to total energy use. The resulting cumulative GHG emissions reduction calculated was on the order of 10^{-5} $MMtCO_2e$. ***CCS is awaiting direction from CAT and TWG on the direction of this target before proceeding to quantify cost-effectiveness.***

Substitute on-farm renewable energy technologies

The first step to calculating the renewable generation sources and how much electricity is projected to be derived from each source. The renewable generation sources that are assumed to have potential on farms in Washington are wind, solar PV, solar thermal, and geothermal. Table X-29 demonstrates the cost (before any incentives) of each technology and Table X-30 displays the assumed market share of each technology.[83]

Table X-29: Annualized Cost of Renewable Generation

Year	Annualized Wind Cost (2005$/MWh)	Annualized PV Cost (2005$/MWh)	Annualized Solar Thermal Cost (2005$/MWh)	Annualized Geothermal Cost (2005$/MWh)
2010	50	576	254	-
2011	49	543	252	-
2012	48	509	250	-
2013	47	476	247	-
2014	46	442	245	-
2015	45	409	243	78
2016	45	409	243	77
2017	45	409	243	76

[83] The figures in these tables are consistent with data and assumption used by the ES PWG in their analysis of ES-2.

Year	Annualized Wind Cost (2005$/MWh)	Annualized PV Cost (2005$/MWh)	Annualized Solar Thermal Cost (2005$/MWh)	Annualized Geothermal Cost (2005$/MWh)
2018	45	409	243	76
2019	45	409	243	75
2020	45	409	243	74

Table X-30: Assumed Mix of Generation

Year	Share of Wind	Share of Solar PV	Share of Solar Thermal	Share of Geothermal
2007	83%	0%	1%	0%
2008	86%	0%	1%	0%
2009	88%	1%	1%	0%
2010	91%	1%	1%	0%
2011	90%	1%	1%	0%
2012	90%	2%	2%	1%
2013	89%	2%	2%	1%
2014	89%	3%	3%	2%
2015	88%	3%	3%	2%
2016	87%	3%	3%	2%
2017	87%	3%	3%	2%
2018	86%	3%	3%	3%
2019	86%	3%	3%	3%
2020	85%	3%	3%	3%

CCS used these shares to determine how much generation would be needed from each resource in order to meet the target remaining after pumping and lighting efficiency measures have been implemented. Renewable generation is assumed to have a value of $0.064 per kWh, consistent with the value used to represent cost of avoided electricity in Washington.[84] The GHG benefit of avoided electricity production is 0.5 tCO_2e/MWh.[85] To calculate the amount of electricity generated from 10 MW of capacity, it is necessary to apply capacity factors, and multiply the product of the rated capacity and capacity factor by the number of hours of operation in a given year (24*365 = 8760 hrs/yr). Wind, solar thermal, solar PV, and geothermal have capacity factors of 35%, 75%, 20%, and 89%, respectively.[86] Tables X-31, X-32, and X-33 display the electricity generated, annual cost, and final results, respectively.

[84] Estimate derived from MWPCC data from RTF analysis, same source as marginal CO_2 emission rate for electricity reductions. This is the simple average (not levelized value) of the marginal dispatch costs for 2010, 2015, and 2020.

[85] Levelized costs, 2008 to 2020. US DOE/EIA data are not available for WA or PADD IV. US DOE/EIA data provide US average wholesale for heating oil of $1.72 per gallon in 2005/2006 heating season. This cost does not include fuel taxes. An appendix to the 2006 Annual Energy Outlook by USDOE/EIA (see http://www.eia.doe.gov/oiaf/aeo/pdf/appendixes.pdf) lists an energy content for distillate oil of 5.799 MMBtu/bbl, or 0.138 MMBtu/gallon. Cost computed used for 2006 price, which is escalated using the trends from AEO2006 distillate oil prices for the Pacific region (see "AEO2006 worksheet in this workbook").

[86] From ES-2 TWG. Geothermal capacity factor from: http://www.geo-energy.org/aboutGE/basics.asp.

The projected cumulative GHG emission reduction is 0.077 $MMtCO_2e$ through 2020. The estimated NPV of this option is a net cost of $1.02 million, with a levelized cost effectiveness of $13.23 per $MMtCO_2e$.

Table X-31: Electricity Generated, by Generation Type

Year	Additional Renewable Capacity (MW)	Wind Generation (MWh)	Solar PV Generation (MWh)	Solar Thermal Generation (MWh)	Geothermal Generation (MWh)
2010	0	-	-	-	-
2011	1	2,772	92	25	31
2012	2	5,507	237	63	125
2013	3	8,205	434	116	281
2014	4	10,866	683	182	499
2015	5	13,490	986	263	780
2016	6	16,078	1,183	315	1,029
2017	7	18,629	1,380	368	1,310
2018	8	21,143	1,577	420	1,622
2019	9	23,620	1,774	473	1,965
2020	10	26,061	1,971	526	2,339

Table X-32: Electricity Generation Cost, by Generation Type

Year	Wind Cost ($MM)	Solar PV Cost ($MM)	Solar Thermal Cost ($MM)	Geothermal Cost ($MM)	Total Cost ($MM)
2010	$0.00	$0.00	$0.00	$0.00	$0.00
2011	$0.14	$0.05	$0.01	$0.00	$0.19
2012	$0.26	$0.12	$0.02	$0.00	$0.40
2013	$0.39	$0.21	$0.03	$0.00	$0.62
2014	$0.50	$0.30	$0.04	$0.00	$0.85
2015	$0.61	$0.40	$0.06	$0.06	$1.13
2016	$0.72	$0.48	$0.08	$0.08	$1.36
2017	$0.84	$0.56	$0.09	$0.10	$1.59
2018	$0.95	$0.64	$0.10	$0.12	$1.82
2019	$1.06	$0.73	$0.11	$0.15	$2.05
2020	$1.17	$0.81	$0.13	$0.17	$2.28

Table X-33: GHG Emissions Reduction and Cost Effectiveness of On-Farm Renewable Energy in Washington

Year	Renewable Generation (MWh)	GHG Benefit (MMtCO2e)	Total Cost ($MM)	Cost Savings ($MM)	Net Cost ($MM)	Discounted Cost ($MM)	Levellized / Discounted CE ($/MtCO2e)
2010	-	-	$0.00	$0.00	$0.00	$0.00	
2011	2,919	0.001	$0.19	$0.19	$0.01	$0.00	
2012	5,931	0.003	$0.40	$0.38	$0.02	$0.02	
2013	9,035	0.004	$0.62	$0.58	$0.04	$0.04	
2014	12,230	0.006	$0.85	$0.78	$0.06	$0.05	
2015	15,518	0.007	$1.13	$0.99	$0.14	$0.11	
2016	18,605	0.008	$1.36	$1.19	$0.17	$0.13	
2017	21,686	0.010	$1.59	$1.39	$0.20	$0.15	

2018	24,762	0.011	$1.82	$1.58	$0.24	$0.16	
2019	27,832	0.013	$2.05	$1.78	$0.27	$0.17	
2020	30,897	0.014	$2.28	$1.98	$0.30	$0.19	
Total		0.077	$12.30	$10.84	$1.46	$1.02	$13.23

- **Key Assumptions:**

The key assumption in this analysis is that the costs of implementing these programs will be incurred through programs mentioned in previous options. The renewable energy portion does not include biogas digesters, which are targeted by AW-1. The generation of electricity from biogas would likely allow Washington farms to achieve much more than 10 MW of renewable generation.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AW-7. Preserve Open Space/Agricultural Land

Mitigation Option Description

The Agriculture & Waste TWG recommends that Washington vigorously implement programs to reduce the rate at which agricultural lands are converted to developed uses, while protecting property rights and responsibilities. By protecting agricultural areas from development, the carbon in above-ground biomass and below-ground soil organic carbon can be maintained and additional emissions of CO2e to the atmosphere can be avoided. It is estimated that approximately 23,000 acres of Washington farmland are converted out of agriculture every year (USDA, 1997 Natural Resource Inventory), contributing significant CO2e emissions through the loss of stored carbon in biomass. Conservation of the agricultural land base can occur through a variety of planning, regulatory, market development, and incentive-based strategies. Conservation of the agricultural *land base* complements and supports the carbon management *farming practices* addressed in AW-4. This option also supports the smart growth policies under options RCI-13 and T-4.

Mitigation Option Design

- **Goals:** The rate at which existing crop and rangelands are converted to developed uses should be reduced. By 2010, agricultural land conversion should be reduced by 30%. By 2020, the rate at which agricultural land is converted should be reduced by 50%.
- **Timing:** By 2010, agricultural land conversion should be reduced by 30%. By 2020, the rate at which agricultural land is converted should be reduced by 50%.
- **Coverage of parties:** Landowners, local governments, relevant state agencies, and non-governmental organizations, Western Climate Initiative.
- **Other:** WA farmland urbanization rate based on NRI = 23,000 acres/yr 1992-1997.
    - By 2020, achieving these goals would save 11,660 acres of land per year from being converted to developed uses. This would retain the above- and below-ground carbon on these lands, as well as the carbon sequestration potential of these lands. Achieving these goals in conjunction with smart growth policies (Options RCI-13 and T-4) may also contribute toward a reduction in transportation emissions through more efficient development and lower vehicle use.

Implementation Mechanisms

- Ensure that any new regional (Western Climate Initiative) or federal cap and trade program allows offsets or trading of verified credits from forestry or agricultural carbon sequestration projects.

- Support the implementation of a vigorous new farmland protection program within the Office of Farmland Preservation. This program should include:
  - Significant new funding for a state-wide program to purchase agricultural easements
  - Economic development assistance to help keep agriculture profitable
  - Environmental compliance/stewardship assistance for farmers (e.g. through programs such as CREP (Conservation Reserve Enhancement Program), Pioneers in Conservation, etc.)
- Increase funding for the Washington Wildlife and Recreation Program, which protects open space and agricultural lands.
- Encourage the expansion and development of Transfer of Development Rights (TDR) programs that use market-based mechanisms to protect the agricultural land base.
- Encourage local governments to establish local funding mechanisms to conserve agricultural land. (e.g., the King County Farmland Preservation Program and the Skagit County Farmland Legacy Program).
- Engage in certification standards to maximize access to voluntary carbon markets from in-state agriculture (e.g. Chicago Climate Exchange eligibility).
- Implement programs that encourage long-term carbon sequestration on appropriate acreage (specific programs addressed through AW – 4).
- Support certification programs that enlist consumer support for climate friendly farming practices.
- Adopt and implement an environmental mitigation policy that protects farmlands.

Related Policies/Programs in Place

- A variety of programs and policies are in place to encourage the conservation of the agricultural land base. These include: agricultural zoning, current use taxation programs, right-to-farm ordinances, local purchase of development rights programs (e.g., the King County Farmland Preservation Program and the Skagit County Farmland Legacy Program), and the Washington Wildlife and Recreation Program (WWRP). During the current biennium, WWRP has funded over $9 million in projects to purchase development rights on agricultural lands throughout Washington state.

- In addition, the 2007 Legislature created the Office of Farmland Preservation in the State Conservation Commission (Chapter 352, 2007 Laws PV). The legislation directs the Office of Farmland Preservation to:
  - Recommend a funding level for a new agricultural easement purchase program
  - Develop model programs and tools, including innovative economic incentives for landowners, to retain agricultural land for agricultural production
  - Provide technical assistance to localities as they develop and implement programs, mechanisms, and tools to encourage the retention of agricultural lands
  - Provide analysis and recommendations as to the continued development and implementation of the farm transition program

- Serve as a clearinghouse for incentive programs that would consolidate and disseminate information relating to conservation programs that are accessible to landowners and assist owners of agricultural lands to secure financial assistance to implement conservation easements and other projects.
- Develop a grant process and an eligibility certification process for localities to receive grants for local programs and tools to retain agricultural lands for agricultural production
- In cooperation with the Agricultural Preservation Task Force, analyze the major factors that have led to past declines in the amount and use of agricultural lands in Washington and of the factors that will likely affect retention and economic viability of these lands into the future.

Types(s) of GHG Reductions

- **CO_2:** Conservation of agricultural lands retains the ability of the land to sequester carbon in soil and biomass. Also, emissions are indirectly reduced to the extent that development patterns are influenced and vehicle miles traveled (VMT) are avoided (see TLU Option 1).
- **CH_4 and N_2O:** Are also indirectly reduced as VMT are reduced (not quantified; potentially addressed by TLU TWG).

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **GHG reduction potential in 2012, 2020 ($MMtCO_2e$):** 0.75, 1.11
- **Net Cost per $MtCO_2e$:** $16.05
- **Data Sources:**

  Land conversion rates are estimated from 1982-1997 land use cover change data from the Natural Resource Conservation Service's National Resource Inventory (NRI).[87] Estimates of soil organic carbon were made from a poster published by the United States Geologic Service (USGS).[88] Cost data was retrieved from an Natural Resources Conservation Service (NRCS) Washington State Fact Sheet.[89]
- **Quantification Methods:**

  GHG emission reductions from land conservation

  Through data provided by the NRCS, the rate of conversion of croplands, rangelands, and pasturelands in WA are displayed for the whole state, Eastern Washington, and Western Washington (Table X-34).

Table X-34: NRI Data – Land Conversion to Developed Use

[87] Natural Resources Conservation Service. WA NRI data provided by the NRCS state office. Provided to S. Roe on August 24, 2007 by J. Carlson via e-mail.

[88] Bliss, N.B., and S.W. Waltman. "Soil Organic Carbon Stocks for the Conterminous United States." United States Geological Survey.

[89] Natural Resources Conservation Service. "FY-2003 Washington Farm and Ranch Lands Protection Program." Accessed on October 22, 2007 from: http://www.nrcs.usda.gov/programs/frpp/StateFacts/WA2002.html.

Total

Time Period	Land converted (acres)	Annual Conversion (acres)
1982-1987	31,100	6,220
1987-1992	72,300	14,460
1992-1997	116,600	**23,320**
1982-1997	224,100	14,940

West

Time Period	Land converted (acres)	Annual Conversion (acres)
1982-1987	21,900	4,380
1987-1992	32,800	6,560
1992-1997	60,000	12,000
1982-1997	118,700	7,913

East

Time Period	Land converted (acres)	Annual Conversion (acres)
1982-1987	9,200	1,840
1987-1992	39,500	7,900
1992-1997	56,600	11,320
1982-1997	105,400	7,027

The option design sets a target of 50% reduction of annual land conversion by 2020. The baseline land conversion that this target is applied to is the average annual conversion for the most recent five years of data, for the entire state. This value is bolded in the above table. The TWG chose to separate the analysis for east and west, due to the differences in soil carbon content between the two regions of the state. As Figure X-2 shows, a reasonable estimate for soil organic carbon content (SOC) in Western Washington is 10 kg C/m^{2,} and 7 kg C/m^2 in Eastern Washington.[90] These figures convert to 40.47 MtC/acre and 28.33 MtC/acre, respectively. Assuming that 75% of SOC is lost through conversion to developed use (on average), the GHG impact of land conversion is 148.38 MtCO$_2$e/acre in Western WA, and 103.87 MtCO$_2$e/acre in Eastern WA. The cumulative estimated GHG benefit achieved through this option is 10.42 MMtCO$_2$e through 2020.

Cost Effectiveness

As reliable data regarding the cost of easements could not be found by CCS in an expeditious manner at the time of analysis, a state-wide average cost of $2,229/acre was applied. The resulting cost analysis yielded a non-discounted cumulative cost of $244.31 million, for an NPV of $167.23 million. The levelized/discounted cost effectiveness is estimated to be $16.05/MtCO$_2$e. Results are displayed in Table X-35.

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[90] Natural Resources Conservation Service. "FY-2003 Washington Farm and Ranch Lands Protection Program." Accessed on October 22, 2007 from: http://www.nrcs.usda.gov/programs/frpp/StateFacts/WA2002.html.

Figure X-2: Soil Organic Carbon in the Conterminous United States

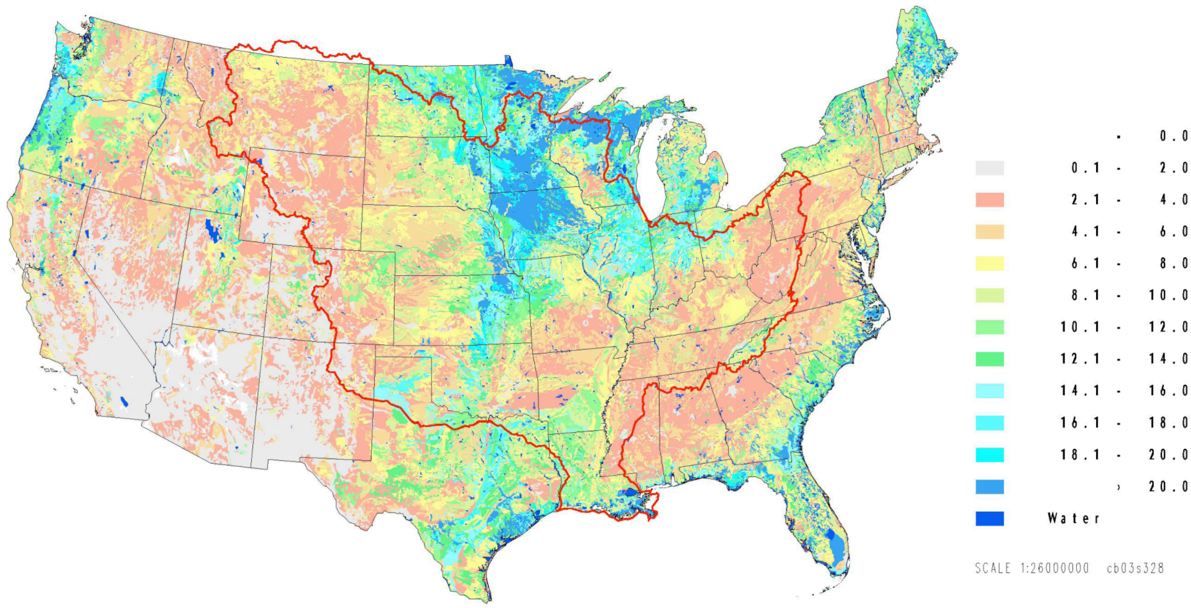

Figure 8. Soil Organic Carbon (kg C m $^{-2}$)

Table X-35: Land Conversion, Carbon Benefit, and Program Cost

Year	Reduced Land Converted (Total, acres)	Reduced Land Converted (West, acres)	Reduced Land Converted (East, acres)	Carbon Sequestered (MMtCO2e)	Cost of easements ($MM)	Discounted Costs ($MM)	Levelized / Discounted CE
2007	-	-	-	-	$0.00	$0.00	
2008	2,332	1,200	1,132	0.22	$5.20	$4.95	
2009	4,664	2,400	2,264	0.44	$10.40	$9.43	
2010	6,996	3,600	3,396	0.67	$15.59	$13.47	
2011	7,462	3,840	3,622	0.71	$16.63	$13.68	
2012	7,929	4,080	3,849	0.75	$17.67	$13.85	
2013	8,395	4,320	4,075	0.80	$18.71	$13.96	
2014	8,862	4,560	4,302	0.84	$19.75	$14.04	
2015	9,328	4,800	4,528	0.89	$20.79	$14.07	
2016	9,794	5,040	4,754	0.93	$21.83	$14.07	
2017	10,261	5,280	4,981	0.98	$22.87	$14.04	
2018	10,727	5,520	5,207	1.02	$23.91	$13.98	
2019	11,194	5,760	5,434	1.06	$24.95	$13.89	
2020	11,660	6,000	5,660	1.11	$25.99	$13.78	
Totals	**109,604**	**56,400**	**53,204**	**10.42**	**$244.31**	**$167.23**	**$16.05**

- **Key Assumptions:** The analysis of this option assumed that one soil organic carbon content value could be placed over all of Western Washington, and another over all of Eastern Washington. Lack of aggregated SOC data by land-use type made this assumption necessary. Since data and/or modeling regarding the carbon content of above ground biomass by land-cover type was not found, the default assumption is to assume that zero carbon is stored in above-ground biomass. This assumption errs on the side of producing a conservatively low estimate of GHG benefit of this option. This analysis also assumes that the cost of land is constant throughout the state. Naturally, depending on the location of the land being converted into easement, the costs can vary greatly. Finally, the benefits of this option are only calculated up to 2020. However, land preserved in perpetuity can have carbon benefits far beyond the end of the policy period analyzed in this report.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

TBD

Feasibility Issues

TBD

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

AW-8: Support for an Integrated Regional Food System

Mitigation Option Description

16% of the U.S.'s total energy use is consumed within the national food system. A regional food system that integrates the whole supply chain (production, processing, packaging, distribution, purchase, preparation, and waste management) in carbon reduction strategies holds significant potential for reducing greenhouse gas emissions. Life cycle assessment research that includes traditionally externalized factor inputs - such as food production practices, transportation method (boat, truck, plane), type of vehicle fuel used in transportation - and addresses more than just food mile measurements, is the first goal and will help determine the actual size of GHG reduction.

A successful regional food system will also provide new markets for regional farms of varying sizes, create new jobs and markets for food and energy companies in state, reduce petroleum use, and strengthen rural communities through the retention and circulation of profits within the regional economy. Ultimately agricultural lands can be preserved since there are now more robust economic options for farmers, which can reduce the risk of farming as a source of financial debt concern.

Low carbon footprint food products improve air, soil and water quality, particularly when integrated with carbon, nutrient, and water management strategies as proposed in other AW TWG strategies. By supporting low carbon food products we support the production of low carbon farming practices, like the use of on-farm renewable energy systems; organic carbon sequestration method including low-till/no-till methods; and agricultural carbon, nutrient, and water management strategies.

A regionally vibrant food system should not penalize current import/export successes, especially those that are working to implement carbon reduction strategies. This policy provides incentives to import/export supply chains that meet our GHG emission goals by rewarding carbon reduction in their existing supply chains for any product that passes through Washington ports and has met stated GHG emission goals.

This option has cross benefits that complement some Transportation, Energy, and the Residential, Commercial, and Industrial TWG mitigation strategies, with potentially larger savings by utilizing low carbon fuel standard fuels, in-state biofuels, and/or for the co-location of renewable energy systems with regional food infrastructure requirements.

This option is focused on impacts and issues after farm production and complements AW TWG options that address farm production, solid waste, and open space and farmland preservation.

Overall, this policy is focused on looking across traditional issues and approaching the issues of GHG emission reduction, increasing clean energy jobs, and reducing fuel imports by integrating various issues, and whole supply chains, in to one cohesive strategy.

Mitigation Option Design

Goals:

- Quantify potential gains through life cycle assessments of current and relevant potential food products by Nov. 1, 2009.
  - Designed around agricultural products optimized for our diverse growing regions.
- Integrate mitigation with cross-sector strategies emerging from transportation, energy, and residential/commercial/industrial technical working groups.
- Increase in-state production, processing, packaging, distribution, demand, and availability of state food for state markets by 2015. Utilize regional food products when appropriate and/or feasible.
- Reduce by 20% by 2020 the transportation distance that individuals, particularly those with limited food choices, have to travel to purchase recommended food such as those included in federal dietary recommendations, by potentially encouraging delivery services that minimize physical store trips and/or by incentivizing the location of food product offerings in underserved communities.

Timing:

- Quantifying research of true potential by Nov. 1, 2009.
- State and local public institutions will lead by example by sourcing local food system products:
  - 15% voluntary increase in dollars spent for regionally sourced products by 2010.
  - 15% required increase in dollars spent for regionally sourced products by 2015.
  - 20% required increase in dollars spent for regionally sourced products by 2020.

Coverage of parties: State Department of Ecology, State Department of Community, Trade and Economic Development, State Department of Agriculture, Office of Superintendent of Public Instruction, private sector.

Other:

-
- Larger gains can be realized by co-locating biofuel, renewable energy and CHP facilities with food processing and distribution centers, and also through incentives to use biofuels for transportation of food ingredients and finished goods.
- Tax revenue and community wealth will increase due to the retention/capturing of economic activity dollars in regional communities. New research on the economic benefits of locally directed spending shows that for every consumer dollar spent at community-based restaurants and groceries, more than 45 cents of additional economic

activity is generated as the spending circulates through the state economy[91]. Regionally-directed activity creates tax revenue that can be used to fund ghg reduction incentives.

- A carbon market mechanism or incentive that includes an economically attractive option for small and mid-size producers will generate an additional increase in economic activity, allowing public and private budgets to utilize precious resources for other items and needs. Money saved from this and other carbon-market related activity can be used to fund incentive packages that support the growth of this and other ghg reduction strategies.
- Food production waste that is sourced from organic and/or biostocks, including livestock manure, dairy waste, and organic municipal solid waste, may be a source of renewable energy for food processing facilities, or at least a viable feedstock for any biofuel or bioenergy processing facilities.

Implementation Mechanisms

- Determine the true potential for regional food system products and services to reduce ghg emissions, increase clean energy jobs, and reduce fuel imports. Quantify potential gains through life cycle assessments of current and relevant potential food products by Nov. 1, 2009.
    - Research current and potential food products that in-state food system can produce.
    - Clarify growing regions of state to distinguish food product potential.
        - 7 regions: NW, SW, North Central (irrigated river valleys), North Columbia Basin (Project irrigated), South Columbia Basin (project irrigated), Yakima Valley (river irrigated), low-precip dryland*, intermediate precip dryland*, and high-rainfall dryland / annual crop zone* (Palouse).[92]
            - **The rainfall zones are west-east transitions, not north-south. They follow the Cascade rainshadow effect.*
    - Determine carbon content, using life cycle assessment methods, of current food products consumed in-state that have comparable in-state production potential, and of potential replacement food products that can be produced, processed, packaged, transported, stored, and/or sold in-state.
        - Include, when feasible, regional products (Oregon, Idaho, British Columbia) that show potential for large carbon reduction gains and/or large clean energy job creation.
        - Consider fuel and energy sources in calculations.
        - Ensure current low-carbon fuel or energy supplies, such as hydropower, are included.
        - Research costs of improving in-state freight rail service (See Transportation TWG option T-6).

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[91] Based on the Sustainable Seattle report "Why Local Linkages Matter: Findings from the Local Food Economy Study", forthcoming October 2007

[92] *Chad Kruger, WSU*

  - Current and potential cost of production of any products determined to contain a lower carbon footprint.
    - Considers, where feasible, potential carbon-market mechanisms including, but not limited to, GHG (carbon) tax, GHG cap and trade, low carbon fuel standard.
- Align state procurement regulations regarding in-state source preferencing.
- Implementation involves coordination across sectors. Related policy options include:
  - T-6: Improvements to Freight Railroads and Intercity Passenger Railroads;
  - T-7: Diesel Engine Emission Reductions and Fuel Efficiency Improvements;
  - T-10: Accelerate and Integrate Plug-In Hybrid Electric Vehicle Use;
  - T-11: Low Carbon Fuel Standard;
  - RCI-2: Targeted Financial Incentives and Instruments to Encourage Energy Efficiency Improvements;
  - RCI-6: Provide Incentives to Promote and Reduction of Barriers to Implementation of Renewable Energy Systems;
  - RCI-7: Provide Incentives and Resources to Promote and Reduction of Barrier to Implementation of Combined Heat and Power and Waste Heat Capture;
  - RCI-8: Consumer Education Programs, Including Labeling of Embodied Life-cycle Energy and Carbon Content of Products and Buildings
  - ES-2: Distributed renewable energy incentives and/or barrier removal;
  - ES-7: Combined Heat and Power (CHP) and Thermal Energy Recovery and Use;
- Port fee incentive for any cargo vessel using bio-based fuels, especially if regionally produced, or that intentionally transports low-carbon food ingredients or products.
- State and local public institutions will lead by example by sourcing local food system products:
  - 15% voluntary increase in dollars spent for regionally sourced products by 2010.
  - 15% required increase in dollars spent for regionally sourced products by 2015.
  - 20% required increase in dollars spent for regionally sourced products by 2020.
- Allocate up to fifteen cents per meal served to incorporate Washington agricultural products in to state agency cafeteria purchases and public school breakfast and lunch programs.
- Encourage co-location of decentralized CHP and renewable energy facilities with food processing, production, and storage hubs.
- Reduce the distance individuals have to travel to purchase food by 20% by 2020.
  - Improve and promote alternatives methods to cars to shop at grocery stores[93].
    - Work with counties to assure transit routes support access to food resources.
    - Consider offering incentives to shoppers who do not use an automobile to travel to a store.
  - Assist communities with limited food choices to identify appropriate locations for locating food products in their communities and neighborhoods.

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[93] Mechanism clauses from recommendations within" Seattle Food System Enhancement Project", Program on the Environment Certificate in Environmental Management Keystone Project, 2006-2007, pp. 57-58, http://courses.washington.edu/emksp06/SeattleFoodSystem/Index.shtml

        - Consider economic incentives or rezoning for retail stores in areas of neighborhood with less food resources.
    - Educate residents about the environmental impacts to using cars to access food resources.
    - Research costs and benefits of encouraging delivery services that can reduce physical store trips.

Related Policies/Programs in Place

- **Federal Incentives**
    - **2007 Farm Bill**
        - As of Oct. 30th still under revision.
    - Value Added Producer Grants (VPAG)
        - Grants may be used for planning activities and for working capital for marketing value-added agricultural products and for farm-based renewable energy. Eligible applicants are independent producers, farmer and rancher cooperatives, agricultural producer groups, and majority-controlled producer-based business ventures.
        - http://www.rurdev.usda.gov/rbs/coops/vadg.htm
    - **Rural Business Enterprise Grants (RBEG) Program**
        - The RBEG program is a broad based program that reaches to the core of rural development in a number of ways. Any project funded under the RBEG program should benefit small and emerging private businesses in rural areas. Small and emerging private businesses are those that will employ 50 or fewer new employees and have less than $1 million in projected gross revenues.
        - http://www.rurdev.usda.gov/rbs/busp/rbeg.htm
    - **Rural Cooperative Development Grant Program (RCDG)**
        - Rural Cooperative Development grants are made for establishing and operating centers for cooperative development for the primary purpose of improving the economic condition of rural areas through the development of new cooperatives and improving operations of existing cooperatives. The U.S. Department of Agriculture desires to encourage and stimulate the development of effective cooperative organizations in rural America as a part of its total package of rural development efforts.
        - http://www.rurdev.usda.gov/rbs/coops/rcdg/rcdg.htm
    - **Appropriate Technology Transfer for Rural Areas (ATTRA)**
        - The Appropriate Technology Transfer for Rural Areas program provides information to farmers and other rural users on a variety of sustainable agricultural practices that include both cropping and livestock operations. The program encourages agricultural producers to adopt sustainable agricultural practices which allow them to maintain or improve profits, produce high quality food and reduce adverse impacts to the environment.
        - http://www.rurdev.usda.gov/rbs/coops/attra.htm
    - **Rural Business Opportunity Grant (RBOG)**
        - The RBOG program promotes sustainable economic development in rural communities with exceptional needs through provision of training and

technical assistance for business development, entrepreneurs, and economic development officials and to assist with economic development planning.

- http://www.rurdev.usda.gov/rbs/busp/rbog.htm

- **Washington State Incentives**
  - **Rural Washington Loan Fund**
    - The Washington State Rural Washington Loan Fund (RWLF) provides gap financing to businesses that will create new jobs or retain existing jobs, particularly for lower-income persons. Only businesses in nonentitlement areas of the state (see map below) are eligible for these loans. "Gap" is defined as that portion of a project which cannot be financed through other sources, but which is the last portion needed before the overall investment can occur. Priority is given to timber-dependent and distressed area projects.
    - http://www.cted.wa.gov/portal/alias__cted/lang__en/tabID__87/DesktopDefault.aspx
  - **Tax-Exempt Economic Development Bonds**
    - Manufacturing and processing projects located in Washington. "Exempt facilities" projects include waste disposal and other types of infrastructure.
    - http://www.wedfa.wa.gov/industrial.htm

Types(s) of GHG Reductions

CH_4: Potential methane reductions from utilization of methane digesters and CHP power sources serving energy to regional processing centers (see AW-1 and Energy TWG ES-7).

N_2O: Nitrous Oxide reductions related to agriculture production practices (see AW-5).

CO_2: CO_2 reductions from lower energy consumption across integrated food system.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **Data Sources:**
  - "Washington State Fact Sheet", USDA Economic Research Service, *http://www.ers.usda.gov/statefacts/* , spreadsheet ("WA-fact-sheet.xls", and pdf downloaded Aug. 25, 2007)
  - Joydeep Ghosh and David W Holland, "The Role of Agriculture and Food Processing in the Washington Economy: An Input-Output Perspective", WSU, August 2004, http://www.impact.wsu.edu/publications/tech_papers/pdf/04-114.pdf

- " Seattle Food System Enhancement Project", Program on the Environment Certificate in Environmental Management Keystone Project, 2006-2007, http://courses.washington.edu/emksp06/SeattleFoodSystem/Index.shtml

- **Quantification Methods:**
  - Unquantified option due to lack of solid data for calculations across supply chains.
  - New research from the University of Washington highlights potential reductions from regional servings of food. Initial calculations to scale up this research have revealed savings between .07-.86 MMT CO2e per year. More research is needed to confirm this early work.[94]
- **Key Assumptions:**
  - Enough in state or regional food production can occur to make a significant reduction in food system related ghg emissions.
  - Impacts to current trade market will not be a deterrent to the scaling up of a regional food system.

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
  - Option not quantified due to lack of solid data for calculations across supply chains and for integrated food systems. More research is needed to validate initial research (see above).
- **Job Creation:**
  - Clean energy jobs will increase related to food processing, transportation, and waste disposal/composting. Some job shifting is expected to occur across the transportation, shipping, and retail sectors.
  - Creation of in-state temporary construction as well as permanent maintenance jobs.
- **Reduced Fuel Import Expenditures:**
  - Reduction in fuel imports will occur from incentivizing biofuel that is feasibly grown and processed in-state, in conjunction with the Low Carbon Fuel Standard. And as through meeting the low carbon fuel standard, production of biofuel feedstocks in-state will lead to more ghg reductions and sequestration within the agricultural sector.

Support for private sector truck fleets to purchase in-state biodiesel will incentive the growth of in-state production markets.

- **Key Uncertainties**

[94] UW report and initial analysis by Tim Crosby available at http://foodsystemfactoids.blogspot.com/2007/10/potential-ghg-reduction-by-locally.html

- Impacts on trade are uncertain.
- Established agriculture businesses will not see value of emerging regional food markets and potential ghg reduction strategies.
- Price of regional food system products, without early government incentives, will inhibit the growth and acceptance for these foods.
- Seasonality and volume constraints will inhibit significant ghg reductions.
- Additional tax revenue generated from local economic food system activity will not be utilized to incentivize the growth and success of an integrated regional food system, and/or government will not direct appropriate spending at critical growth stages to allow emerging markets to reach critical mass.
- For state lead by example efforts, tracking impacts by dollars instead of volume of food purchased will be easier. The impacts on final food prices are less clear. If government does not support appropriate incentives food prices for some purchases will most likely increase especially in the short term, or until market forces rebalance with continued growth of emerging market.

Additional Benefits and Costs

- Tax revenue and community wealth will increase due to the retention/capturing of economic activity dollars in regional communities. Regionally-directed activity creates tax revenue that can be used to fund ghg reduction incentives.
- New research on the economic benefits of locally directed spending shows that for every consumer dollar spent at community-based restaurants and groceries, more than 45 cents of additional economic activity is generated as the spending circulates through the state economy[95].
- A shift of 20% of our food dollars into locally directed spending would result in a nearly half billion dollar annual income increase in King County alone and double that in the Central Puget Sound region[96].
- Dollars spent at local food economy restaurants and groceries have more than twice the usual impact of spending at restaurants and groceries on the income of upstream suppliers[97].
- A regional food system can assist food security and risk mitigation strategies by decentralizing food production, thereby reducing the impact of any crop failure, disease, or terrorist attack on the national food supply.

Feasibility Issues

TBD

[95] Based on the Sustainable Seattle report "Why Local Linkages Matter: Findings from the Local Food Economy Study", forthcoming November 2007

[96] Ibid.

[97] Ibid.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD